J. RUSSELL SMITH

M. OGDEN PHILLIP

THOMAS R. SMITH

CONSTABLE AND COMPANY LTD

Emeritus Professor of Economic Geography, Columbia University

Wilson Professor of Economics, Washington and Lee University

Professor of Geography, The University of Kansas

Industrial and Commercial Geography

FOURTH EDITION

LONDON

Many of the maps and charts in this book were prepared under the direction of Professor George F. Jenks of the University of Kansas.

Library of Congress Card Catalog No. 55-6034

June, 1959

LONDON: PUBLISHED BY *Constable and Company Ltd*
10–12 ORANGE STREET W.C.2

INDIA: *Orient Longmans Private Ltd*
BOMBAY CALCUTTA MADRAS

SOUTH *and* EAST AFRICA: *Longmans, Green and Company Ltd*
CAPETOWN NAIROBI

AUSTRALIA *and* NEW ZEALAND: *Thomas C. Lothian Pty. Ltd*
SYDNEY ADELAIDE MELBOURNE PERTH BRISBANE
AUCKLAND (N.Z.)

28001–0215

Printed in the United States of America

Preface

WE HAVE had a disappointment. We expected to finish this book one full year sooner than we did. But there have been too many revolutions to report, revolutions in industries, revolutions in trade, revolutions in government, revolutions in the minds of men. Some understanding of these changes is needed if you, the readers, are to step forward intelligently into the decade ahead of you.

To cover these changes as fully as space permitted, we had to do much study, much rearrangement, much rewriting. This is not just a revised edition. If you know the previous edition you will call this a new book.

The 1946 edition was written as an epoch ended. For a quarter of a century we had been talking and thinking about "one world." We had been securing materials from everywhere. We got materials from scores of countries to make an automobile—from three or four continents to make a shoe. We passed from the idea of world trade to one world.

The one world idea is self-centered: *our* automobile, *our* shoe, *our world.*

Enter Mars and World War II. By the time we had got Mars seated, and had looked about the world a bit, we discovered hunger, misery, nations paralysed and without power of reentering the old economic orbits. A new idea began to dawn upon the Western World—there are two kinds of countries—two worlds, the world of Developed Countries and the World of Underdeveloped Countries.

This idea crystallized into the terms: the *Developed World* and the *Underdeveloped World!* This is a shift of attention and an added emphasis. We are still thinking of world industries, cotton for example. Egypt is still a country that exports fine cotton, but we have begun to think about Egypt as a *country* and Egyptians as a *people* and as a *nation.* If you should take the trouble to find out how many billions Uncle Sam has spent on and in the underdeveloped countries in the last decade, you will agree with us that thinking about this new idea has been very expensive to our national treasury; also it has been one more thing to take up time in rewriting this book.

This new classification and this shift of thought to the nations *as nations* is a natural result of World War II and of the organization and operation of the U. N.

The developed nations are those that have advanced manufacturing industries. Graph after graph in this book shows that they must have ever-increasing quantities of raw materials, and it turns out to be the job of the underdeveloped peoples to furnish raw materials. They become "hewers of wood and drawers of water" for the developed countries. And what is worse, it may almost be said that we, the developed, take their raw materials at our own price. Here is the way it happens. For many commodities we, the developed, are almost the only bidders. Many of the underdeveloped are one-product countries in export trade. If the price of coffee rises high, Rio de Janeiro shines with new automobiles. If it is low, Brazil groans and blames the United States. Boom in United States and Europe sends prosperity to the copper miners of Chile. Depression cuts the price in half or even more, and Chile nearly starves. A crash in the tin market brought the people of Bolivia Plateau so near to starvation that the U. S. Congress tucked a few million dollars into the Mutual Defense Act of 1954 to buy food for tin miners of Bolivia. It is specifically mentioned in the text of that amazing statute.

We think you will be interested in this idea

of the one-product underdeveloped country as illustrated by our short account of Egypt on pages 69–70.

In calling your attention to that discussion of Egypt we also illustrate the fact that this book gives more attention to the human factor in industry than its predecessor did. An industry requires raw materials, men, physical climate, power, and markets. And more. The complexities of modern scientific industry make it increasingly dependent on what we might call the cultural climate under which the people live and work. *Why* are so many countries underdeveloped? We think we give you the answer to that question, and it is something you must live with in the years immediately ahead.

Most of the readers of this preface in the year 1955 have probably read some part of the current discussion of agricultural surpluses—how our Secretary of Agriculture has filled all warehouses and has gone to storing butter in a cave in Kansas. The agricultural surplus is an industrial factor almost as potent as drought. We call attention to it here as one more bit of the human element that we present, because it combines with earth factors to affect world industry.

It is also true that we have managed to squeeze into this edition some new bits of industrial development; perhaps it might be called history. It aids in understanding the present, helps to answer "Why?"

We have had to handle all these new things and also reduce the size of the book. Therefore, this edition differs from the preceding in several respects. Five long chapters have been divided into two chapters each, fourteen chapters dealing with trade and transportation have been condensed to seven chapters, and the number of footnotes has been reduced sharply.

A world industry needs a setting—background. We open with four background chapters: (1) the divided world in which we live, (2) the role of animate and inanimate energy in human affairs, (3) world climate regions, and (4) the place and nature of agriculture.

A better balance is achieved in the space devoted to man's major economic activities—agriculture, grazing, fishing, forestry, mining, manufacturing, transportation, and trade.

This arrangement avoids duplication by students who take continental or regional courses in geography. It results in a better answer to geography's three great questions—what, where, and why. This functional type of presentation makes it easy to present logically man factors and earth factors and their interrelation.

We believe that teachers will find much valuable bibliographic material in the footnotes. In order to reduce the number of footnotes to a minimum, the sources of many easily findable facts and statistics are omitted because of common property, such as the multiplication table and other common property such as *Foreign Commerce Yearbook, Minerals Yearbook, Agricultural Statistics, Statistical Abstract of the United States,* and the *U. N. Statistical Yearbook.*

Throughout this book, references are made to maps, graphs, diagrams, and other illustrations. This is done by referring to the page upon which they appear. Thus, "See Fig. 4" refers to the map on page 4. This saves readers time.

Classes using this book are urged to see to it that the members have access to regular file of *The New York Times,* weekdays. You will be astonished at the number of articles dealing with matters presented in this book. The Sunday issue is such a mountain of material that it would be hard to manage. Another newspaper to follow is the *Christian Science Monitor,* Boston, one of the very best newspapers in the world. It makes little difference if you are in a small city on Pacific Coast. Economic information that reaches you on Monday the 8th of the month is just about as good for your purposes as it was on Monday, the 1st.

Maps are vital to the study of geography. We wish we could have published more, but a textbook cannot also be an atlas or an encyclopedia. Every student needs an atlas. Every home of persons who can read also

needs an atlas. You can perhaps meet two needs if you get *Goode's World Atlas.* Its maps are European in quality.

The creation of this book would have been impossible without the cooperation of many friends. We are indebted to many corporations, governmental agencies, and specialists, and to personal friends in this country and overseas for honoring our requests for aid. We thank Miss Myra Light, who as secretary has wrestled with manuscript problems of mountainous size. Most authors know that an author's wife should be endowed with the patience of Job. For eternal patience, constructive advice, and home environment never lacking in encouragement, we are grateful to Henrietta Stewart Smith, Jane Agnor Phillips, and Eleanor Pancoast Smith.

Swarthmore, Pa. J. R. S.
Lexington, Va. M. O. P.
Lawrence, Kans. T. R. S.
April 1955

Content

PA

America Discovers the World—Two Worlds

1. The American People Dozed Past the Red Light. 2. Waked by a Series of Shocks. 3. Stung into Action. 4. How Did We Get a High Standard of Consumption in Our Own Country and in Europe? 5. Capital Is Needed to Improve Economic Status. 6. Difficulties in Getting Foreign Capital. 7. Independence, Turkish Style. 8. Political Aspects of Economic Development in Latin America. 9. Capital Is Waiting. 10. What Is the Prospect for Improved Production in Underdeveloped Countries in the Decades Immediately Ahead? 11. The Two Worlds and the Number 1 World Problem. 12. What Can Be Done about It?

2. The Role of Animate and Inanimate Energy 1

1. Human Energy and Progress. 2. Animal Power. 3. The Mechanical Revolution: Divider of Mankind. 4. Animate *versus* Inanimate Energy in the World of Today

3. World Climate Regions 4

1. Type—the Idea and Its Use. 2. The Cotton Belt, a Subtropic Climate. 3. Equatorial Forest. 4. The Tropical Grasslands. 5. The Desert Belts. 6. West-coast Marine Climate Regions. 7. The Continental Interiors. 8. The Small Grain, Potato, and Grass Climate Regions. 9. The Great Northern Forest. 10. The Tundra and the Icecaps. 11. Where Can Civilizations Arise?

4. The Place and Nature of Agriculture 5

1. The Food Gatherer. 2. Primitive Agriculture. 3. Modified Primitive Agriculture. 4. The Domestic Animals Make an Epoch—A Long One as We Count Time. 5. This Domestic Era. 6. Commercial Agriculture and Continental Interiors. 7. Machines Make a World Market. 8. World War II and the American Farm Boom. 9. The U. S. Government Meets the Glut by Storing Crops. 10. Why Not Export the Food? 11. Will Our Wheat Export Disappear? 12. Export by an Agricultural Country That Lacks Manufactures. 13. Ups and Downs for the Country with One or Two Raw Exports. 14. The Overdeveloped Country

5. Wheat—The World's Prime Breadstuff 7

1. The Wheat Plant and Its Climatic Requirements. 2. Regions with Good Wheat Climate. 3. Technology, Science, and Wheat. 4. Wheat in Sparsely Populated Regions. 5. The Production of Wheat in Europe. 6. Soviet Wheat. 7. Wheat in eastern and southern Asia. 8. The Manufacture of Wheat Products. 9. Wheat Trade and the Future Supply

PAGE

6. Rice—The Great Foodstuff of the Orient 94

1. The Importance and Use of Rice. 2. The Rice Environment. 3. The Production of Upland and Lowland Rice. 4. The Spread of Rice-growing. 5. Growing Rice by Machinery in the United States. 6. Rice Trade and Wars

7. Corn, Rye, Oats, and Other Cereals 105

1. Corn (Maize). 2. Rye. 3. Flax. 4. Oats. 5. Barley. 6. Millet and Sorghum. 7. Buckwheat

8. The Vegetable Industries 124

1. Vegetable Production and Trade. 2. Peas and Beans (Pulse). 3. The White Potato. 4. Sweet Potatoes and Cassava

9. The Fruit Industries 137

1. The Banana. 2. The Apple. 3. The Peach. 4. The Citrus Fruits. 5. The Grape and Wine Industries. 6. Dried Fruits. 7. The Canning and Freezing of Fruits and Vegetables

10. The Beet-sugar and Cane-sugar Industries 164

1. The Beet-sugar Industry. 2. The Cane-sugar Industry. 3. Major Cane-sugar Producers. 4. Other Sources of Sugar

11. Condiments and Tobacco 184

1. Coffee. 2. Tea. 3. Cacao. 4. Spices. 5. Tobacco

12. The Animal Industries 207

1. Meat and the Meat Supply. 2. Sheep and Other Wool Bearers. 3. Beef Cattle. 4. Swine (Hogs). 5. Meat Packing

13. Dairy Products, Vegetable Substitutes, and Small Animal Industries 229

1. The Dairy Industry. 2. Dairy Substitutes. 3. Poultry and Small Animals

14. The Fishing Industry 243

1. The Nature and Importance of Fishing. 2. European Fisheries. 3. Atlantic Fisheries of North America. 4. Pacific Fisheries of North America. 5. Asiatic Fisheries

15. Leather, Furs, and Rubber 254

1. The Raw Materials for Leather. 2. Leather Manufactures. 3. Furs. 4. Crude Rubber. 5. The Manufacture of Rubber

PAGE

16. The Fundamentals of Manufacture **267**

1. The Nature of Manufacturing. 2. Locational Factors and Forces. 3. Minerals and Manufacturing

17. Coal—Prime Source of Energy **283**

1. The Origin and Importance of Coal. 2. British Coal Production and Trade. 3. The United States Coal Industry. 4. Canadian, Alaskan, and Latin American Coal. 5. Coal in Western Europe. 6. The Coal Resources of the Soviet Union. 7. The Coals of Asia, Australia, and South Africa. 8. Methods of Mining Coal. 9. The Utilization of Coal

18. Petroleum and Natural Gas—Fugitive Fuels **306**

1. The Importance and Use of Petroleum. 2. The Origin and Nature of Petroleum. 3. The Oil Fields of the United States. 4. Foreign Oil Fields. 5. Petroleum Refining, Transportation, and Trade. 6. Substitutes for Petroleum. 7. Natural Gas

19. Water Power—A Permanent Resource **328**

1. The Significance of Water Power. 2. The Potential Supply of Water Power. 3. The Development of Water Power. 4. Other Sources of Power

20. Iron and Steel—The Backbone of Modern Industry **340**

1. The Age of Iron and Steel. 2. The Formation, Distribution, and Mining of Iron Ore. 3. The Development of Iron Manufacture. 4. The Development of Modern Steel Technology. 5. Size, Integration, and Locational Factors

21. The Distribution of Iron and Steel Manufacture **354**

1. The Major Steel Regions. 2. The American Iron and Steel Industry. 3. Canadian Iron and Steel. 4. The British Iron and Steel Industry. 5. Iron and Steel Production in western Europe. 6. The Soviet Steel Industry. 7. Iron and Steel Manufacturing in the Orient. 8. Steel Centers in the Southern Hemisphere. 9. World Trade in Iron and Steel

22. The Copper Industry **380**

1. The Usefulness of Copper. 2. The Occurrence and Mining of Copper. 3. The Technology and Location of Manufacture. 4. Westward Migration of U. S. Copper Production. 5. South American Developments. 6. Copper in Africa. 7. Canadian, Soviet, and Other Developments. 8. Copper Resources and World Trade

23. Aluminum, Tin, Nickel, and Other Mineral Industries **395**

1. Aluminum. 2. Magnesium. 3. Titanium. 4. Tin. 5. Nickel. 6. Lead. 7. Zinc. 8. Gold. 9. Silver. 10. Platinum. 11. Diamonds

PAGE

24. Nonmetallic Mineral Building Materials **421**

1. The Early and Late Importance of Nonmetallic Minerals. 2. Clay and the Brick and Tile Industries. 3. Granite, Marble, and Slate. 4. Limestone, Sandstone, and Trap Rock. 5. The Cement Industry. 6. Pottery and Porcelain. 7. The Manufacture of Glass

25. The Metal-fabricating Industries **433**

1. The Machine-tool Industry. 2. Industrial Machinery. 3. The Manufacture of Agricultural Machinery. 4. The Manufacture of Railway Cars and Locomotives

26. The Metal-fabricating Industries (continued) **444**

1. The Automobile Industry. 2. The Aircraft Industry. 3. Shipbuilding. 4. Small Metal Manufactures

27. Chemical Raw Materials and Manufactures **461**

1. Chemistry in the Laboratory and Factory. 2. The Rise of the Chemical Industry. 3. The Raw Materials. 4. The Manufacture of Explosives. 5. The Fertilizer Industry. 6. Soap Making and Its Materials. 7. Coal-tar Dyes. 8. Plastics

28. Forests and Forest Products **481**

1. The Dynamic Nature of Forest Resources. 2. Forest Depletion and the Migration of Lumbering in the United States. 3. The Lumber Industry in the United States. 4. Canadian and Alaskan Forests. 5. The Intensive Utilization of European Forests. 6. Forests in the Temperate Lands of Asia and the Southern Hemisphere. 7. The Tropic Forest and Its Products. 8. Naval Stores. 9. Wood Manufactures. 10. The Manufacture of Paper

29. Vegetable, Animal, and Man-made Fibers **505**

1. The Supply of Raw Cotton. 2. Cotton in the United States. 3. Foreign Cotton-producing Areas. 4. Wool—the Premium Natural Fiber. 5. Silk—the Fallen Queen. 6. Man-made Fibers. 7. The Plant-stalk Fibers. 8. The Hard Fibers

30. The Textile and Clothing Industries **530**

1. Manufacture and Trade in Cotton Cloth. 2. The Wool Manufacturing Industry. 3. The Manufacture of Silk and Synthetic Textiles. 4. The Manufacture of Linen. 5. Commercial Clothing Manufacture

31. Bases of Trade **550**

1. Differences in Peoples. 2. Difference in Stage of Industrial Development. 3. Differences in Available Material Resources. 4. Differences in Climate Make Trade. 5. Social Conditions and Politics—the Things That Man Does through Govern-

PAGE

ment. 6. Location for Trade and Amount of Trade. 7. Volume of Trade and Trade Statistics

32. The Trade Center and Its Development **561**

1. The Development of Commercial Centers. 2. Seaports and Their Hinterlands. 3. The Entrepôt Center. 4. The Bargain Center

33. Rail and Water Routes of North and South America **579**

1. Railway Patterns and Routes of North America. 2. The Inland Waterways of North America. 3. The Railroads of South America. 4. The Rivers of South America

34. Rail and Water Routes of Eurasia, Africa, and Australasia **598**

1. The Railroads and Waterways of Europe. 2. Rail and Water Routes of the Soviet Union. 3. Land and Water Routes of Asia. 4. The Railroads, Rivers, and Lakes of Africa. 5. Railway Development in Australasia

35. The Ocean and Its Carriers **614**

1. The World Highway. 2. Tramp and Liner Shipping. 3. The Decline of the Tramp. 4. The Postwar Status of the Shipping Industry

36. The World's Overseas Trade Routes **626**

1. The North Atlantic Route. 2. The Routes of Caribbean America. 3. The East- and West-coast Routes of South America. 4. The Mediterranean-Asiatic Route. 5. The South African Routes. 6. Transpacific Routes. 7. Suez and Panama—Vital Gateways of Commerce

37. The World's Airways **643**

1. The Air Age. 2. Air Technics, Politics, and Economics. 3. Airways of the Future

38. Retrospect and Prospect **653**

1. The Sanitary and Health Revolution Improves Health, Increases Population, Creates World Population Problem. 2. The Industrial Revolution. A Multitude of New Devices, Machines, and Methods Change Man's Relation to the Earth in Many Ways. 3. The Revolution in Communications. Airplane, Submarine, Radio, Radar, and Television Have Increased Ease and Speed of Travel, and Spread of Information and Misinformation; Increased the Ease of Adult Education and of Propaganda for Overturning Governments and Enslaving Peoples

Index **672**

1· America Discovers the World—Two Worlds

1. THE AMERICAN PEOPLE DOZED PAST THE RED LIGHT

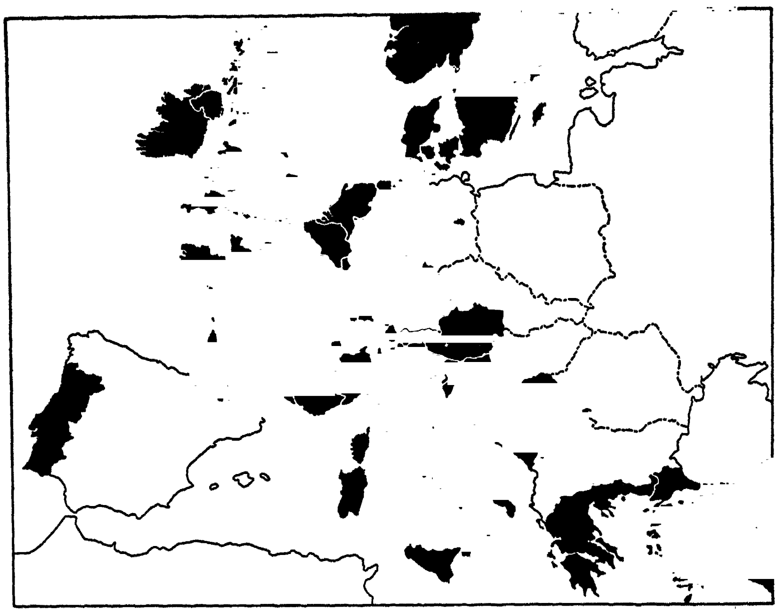
During the half-century before World War II enterprising persons in the United States and northwestern Europe made many scientific discoveries, inventions, new products, new machines, new powers for making useful things. Industry grew. Business enterprises grew larger, reached farther. People began to talk about world industries. During that half-century there was great increase in trade, in wealth and standards of living (consumption), but this was mainly among the machine-using peoples.

The term "one world" was used more and more when people were thinking in terms of business, geography, and world affairs. Interdependence grew both as a fact and as an idea. One world is a two-way idea, exchange of products—mutual dependence—interdependence. It even takes several continents to supply the makings of the shoe on your foot. Radar, radio, electronics, and the age of gadgets make us more and more dependent upon some rare mineral dug out of a hole in some wilderness you never heard of. Interdependence has grown, is growing.

The League of Nations. World War I showed that business affairs, economic life, and the relations between nations called for more orderly procedure than could be had by six great powers and 60 lesser nations working in complete independence.

At the end of World War I, Woodrow Wilson saw this need for better world order. He launched the League of Nations in the hope of ending world wars. The American mind was not ready, and Wilson tried in vain to persuade the American Congress to join the League, but the American people dozed past the red light. Calamity was guaranteed by ignorance. The verdict was, "Let Europe stew in its own juice." It did. It stewed and boiled over in World War II, and the whole world got burnt.

The end of World War II was the end of a 20-year period of active spreading of international information by way of radio, airplane, moving picture, and the mental goadings of war. We got new ideas about the world. The world got new ideas about us. Millions of Americans have heard the voice of the King or Queen of England—and so on around the world. For years the films of Hollywood have gone to every continent. Today something happens in Chicago or Washington, and in an hour a voice on the radio tells the news to millions in London, Cairo, Moscow, Tokyo, Peiping, and even darkest Africa. And tomorrow morning the news will be in the papers in Patagonia, Pakistan, Alaska, Africa, Australia —everywhere.



War is expensive. We helped win World War II, discovered that both ally and enemy were broke. We fed and equipped both ally and enemy—$12 billion to these countries from April 1948 to Dec. 31, 1951, about $3 billion to our late enemies. *European Recovery and Defense Program*

2. WAKED BY A SERIES OF SHOCKS

Those Americans who began World War II still nursing isolationist hopes found themselves in a new world at the end of the war. This new world introduced itself by a series of sharp shocks that came in quick succession.

Shock No. 1—Arabian oil. After decades of world leadership in the production and export of petroleum products, we suddenly found ourselves to be importers, not only from South America but also from far Arabia. The new demands for petroleum for heat and power gave us a keen and enduring interest in pipe lines across the Arabian desert, lines built by scores of millions of American dollars. Oil from the Middle East had suddenly become a top factor, and a dangerous one, in international politics.

Shock No. 2—We went abroad for iron ore in a big way. Our iron masters knew that the rich ore deposits of the Upper Lakes were approaching the end. One group spent some $300 million to open an iron-ore field in Labrador; they got the first cargo in 1954. Meanwhile other U. S. companies were starting big diggings in Venezuela (first cargo in 1951) and in Liberia. Thus we keep our steel industry going—steel, the backbone of modern industry.

But the iron ore beside the blast furnaces cannot support our steel industry without manganese, chrome, nickel, and other metals of which we have almost none within our territories. As industry grows in complexity we must import an increasing amount and number of these essential minerals.

Shock No. 3—The atomic bomb started a world search for materials. The explosion of atomic bombs in August 1945 sent a chill of continuing uneasiness through millions of souls in many nations. It also sent prospectors to the ends of the earth looking for certain minerals, especially for fissionable materials to supply more atomic bombs. Prospectors' success in Canada helps to explain the investment of $1400 million (American) in Canada in the period January 1, 1950, to July 1, 1952. The search continues.

The report of the President's Materials Policy Commission (Paley Report, June 1952)

showed alarming scarcities of U. S. supplies, in relation to their use:

1. *Common metals:* copper, lead, zinc and tin

2. *Additive metals:* manganese, chromium, nickel, molybdenum, tungsten, and 4 others

3. *Twenty-five other metals and resources* were named in the list of scarce or absent.

Minerals, minerals, minerals to the fore! Some say we have a mineral civilization. When our colonial ancestors founded the United States, a few pounds of blacksmith's iron per capita supplied a citizen for a year. Today we use over half a ton of steel per person, several tons of coal, and astounding amounts of copper, zinc, and aluminum.

Check over the list of gadgets that mark the high standard of consumption—auto, radio, refrigerator, plumbing, central heat (fuel and fittings). And war has become machinery. Warfare demands shiploads of machines—metal, metal, metal, and power (oil) to run it all.

Minerals loom bigger and bigger in daily life, in industrial geography, and as major irritants in international politics. And many of them we must import. We are not so independent as we were in homespun days. Knowledge of geography is becoming more important for industry and government as well as for the educated person.

Shock No. 4—World War II showed us our abiding interest in Europe. As World War II dragged on, we discovered anew that western Europe's interest was also our interest. We poured supplies and munitions free of charge into that agonized continent during the war years. We thought it was a temporary measure. When the fighting stopped, we found that the Europeans had to buy food and raw materials to revive their economic life and that they had nothing with which to pay. Chaos threatened, and the United States showed the reality of its interest in Europe by sending billions of dollars worth of grain, meat, machines, and raw materials to help Europe start again. These were straight gifts. We said it was temporary and it would stop in 1952.

Shock No. 5—A double shock: the U. S. S. R. and her ambition. After the collapse of the western European nations at the end of World War II, we stood aghast as we discovered, first, that, for the moment at least, there were but two great powers, the United States and the Soviet Union, and, second, that the U. S. S. R. wished to dominate the world and apparently had mature and active plans to do so. We had demobilized our World War II military establishment. The fear of Russia caused us to reverse, rearm, and seek allies.

We took another long step across the sea. Our postwar situation showed that we needed foreign materials, we needed foreign friends, we needed allies. We helped promote the U. N. and the North Atlantic Pact. You have a measure of one interest in foreign affairs by noting that on January 1, 1955, men wearing the uniforms of U. S. armed forces were in many countries (Fig. 4).* In most countries there were missions or groups; in some, fully equipped divisions. In every country they were backed up by appropriations, totalling billions, for the Mutual Security Act of 1954.

Shock No. 6—We "discovered" the hunger of a billion people. From the first reports by the United Nations' research workers we learned that fully half the people of the world were undernourished according to present knowledge of body needs. They are still undernourished. There was or is nothing new about this, except one thing: their plight has entered American thinking and world thinking and is now a factor in international politics.

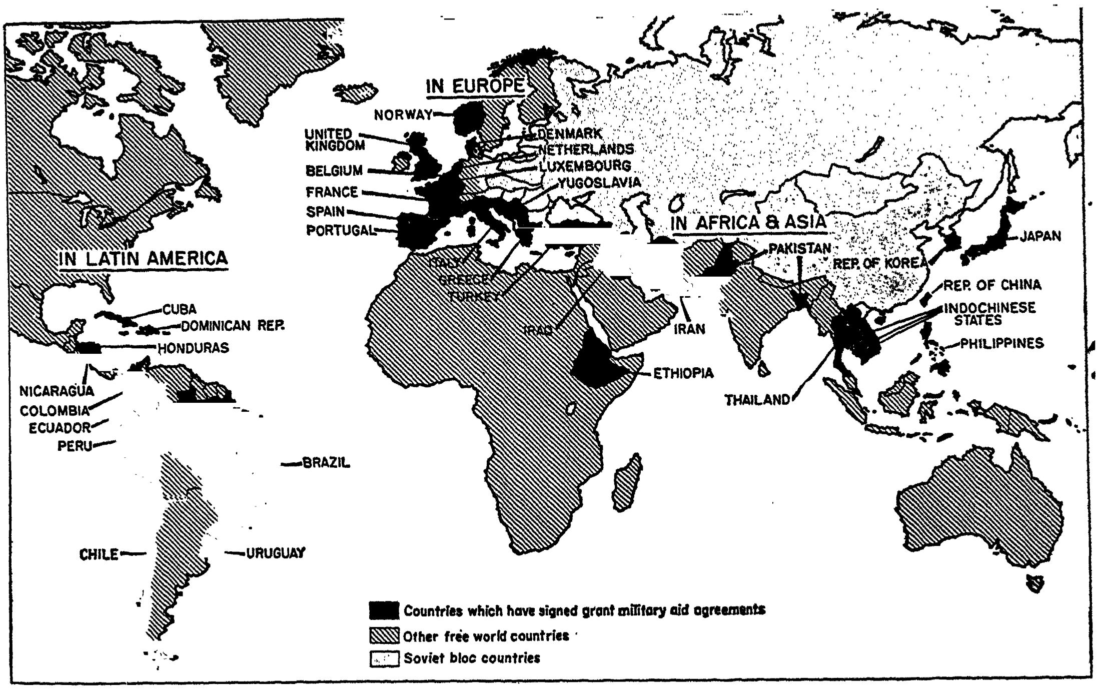
Hunger now has three new aspects:

(1) The World War awakening gave a new idea to illiterate, hungry millions. Those who had known only misery got the idea that they themselves might have better things.

(2) We of the well-fed West have begun to take notice of the hungry ones.

(3) Membership in U. N. has given new prestige to "little nations." They are

* Fig. 4 *refers to illustration on page 4.*



An appropriation in 1954 provided the support for U. S. military personnel in these countries for 1955. *Mutual Security Act of 1954.* According to *The New York Times,* Dec. 5, 1954, numbers of U. S. troops outside U. S. were: Caribbean, 10,000; western Europe, 350,000; Middle East and Mediterranean, 50,000; Korea and Japan, 430,000; Pacific islands, 35,000; Aleutians and Alaska, 30,000; total—905,000.

members of U. N.; they are represented in the council of the world. This gives them a chance to tell the world about the condition of their people and to learn how other nations live. Hope rises where hope had not been before.

Many observers agree that the new knowledge causes millions in Asia and Africa to think they now see a chance to change things in their countries for the better. Have you not heard it said that hunger breeds revolution? Promotes communism?[1]

Shock No. 7—China, India, and Indonesia suddenly changed status. They had been somewhat interesting to us as dense populations with vast numbers having low standards of consumption but with small trade and small force in the world. Suddenly we found they had to be reckoned with as factors in world politics.

3. STUNG INTO ACTION

We helped to found the United Nations. Mental ferment was not limited to Asia, Africa, and the hungry. We also had mental ferment. Before the fighting stopped, the American people were sure that the old 1919 policy of letting the nations drift alone could not be continued. We were active in organizing the United Nations, but that was not all.

The underdeveloped countries. It was further realized that most of the world's hunger was not a direct or even an indirect result of World War II. The people of many lands in several continents were hungry because they did not grow enough food to feed themselves. Could they? A chorus of voices in many quarters said they *could,* but that their resources were not being fully or wisely used. The term "underdeveloped countries" suddenly rang round the world.

[1] Millions of people now say *communism* when they refer to the Russian plan and desire to rule the world —Russian imperialism. Look up the word in a good dictionary ten years old and see the fleeting nature of meanings.

These two ideas of developed and underdeveloped countries as used in the United States in the period of postwar rethinking were somewhat as follows. The United States, Canada, and western Europe spent two centuries building up industries that use mechanical power in the factory and on the farm. This has produced great quantities of material that permitted a high standard of consumption. These lands of power factories and scientific farming are the *developed countries.* Their standard of consumption is much higher than is possible in most of the other countries of the world, especially those that have few power-driven factories and an agriculture that depends chiefly on the muscle of man and his beasts of burden.

The American people came out of the daze of war and postwar discussions with two stunning convictions: (1) if the West is to remain stable, we must keep on helping Europe, and (2) we must do something for the underdeveloped countries. Our aid to Europe did not stop in 1952 as we had said it would. Indeed when Congress adjourned in August 1954, it had appropriated more than $5000 million to be spent abroad for military and economic ends in the ensuing fiscal year.

The Point Four law. Perhaps the most remarkable part of this overseas venture was a law commonly called Point Four.[2] By this act, without precedent in human history, the United States appropriated hundreds of millions of dollars and sent hundreds of technical experts to many countries. They went free of charge with machines, seeds, breeding stock, and American "know-how." These experts went out to help especially the people of so-called underdeveloped countries.

Their success depends in part upon how much the agents know about people, especially the people and the land where they are trying to help. The problem of helping other peoples is one of applied geography and also of applied psychology. Wise legislation and wise foreign policy depend on geographic knowledge among lawmakers, and among citizens, and especially among those who administer laws, especially Point Four.

Can the Point Four agents take the American standard of consumption to foreign lands? Can they plant it in Iran, Burma, Guatemala, or Ecuador and come home in a few years, leaving the nations transformed and without that upsetting factor of hunger?

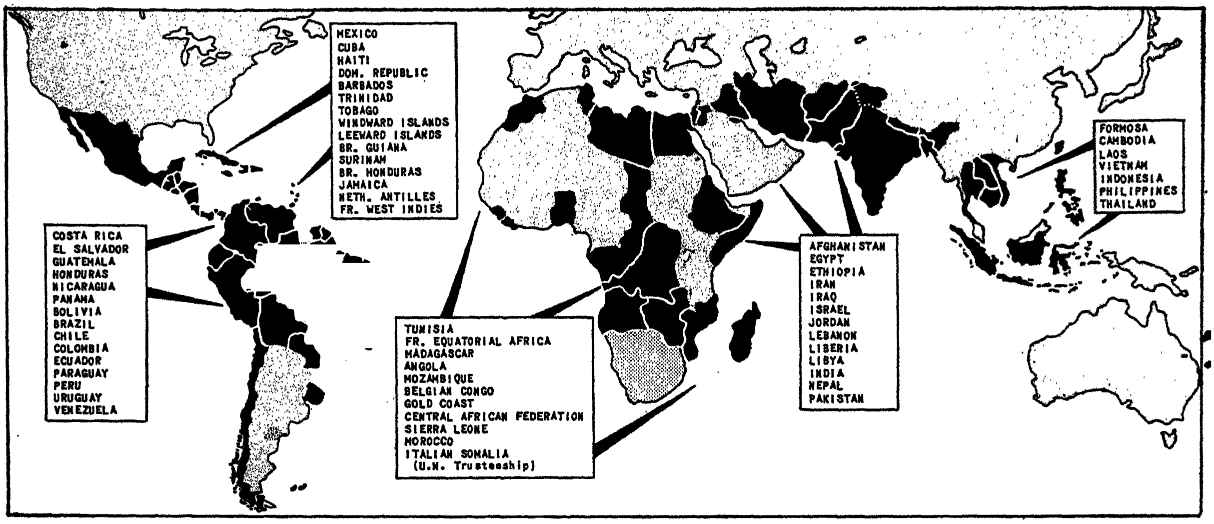
In attempting to answer that difficult question, it will help if we ask another one.

4. HOW DID WE GET A HIGH STANDARD OF CONSUMPTION IN OUR OWN COUNTRY AND IN EUROPE?

Machines make wealth. The answer to the question appears to be simple—we use machines. Machinery has so multiplied our capacities for production that we are able to pay the worker $5, $10, $15, $20, and even more per day in the United States. European wages are below those of the United States, but they are several times as high as those in many other lands where hundreds of millions do most of the work without the aid of machines. Millions of these workers get $1 a day, often less. Can we take machines to these people, teach their use, and let the people make or buy more machines and raise their standard of consumption? Will the American type of industry and consumption follow the kerosene lamp, the simple sewing machine, the radio, the truck, the auto (a few), and the Point Four technician to the ends of the world?

Machines are only a part of the story. We have good climate, abundant raw materials, and a government that helps the people and also leaves them and their enterprise relatively free. These factors and others have combined to permit and help machines to use our ma-

[2] In his Inaugural Address in January 1949 President Truman said: "We must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas. . . . Democracy alone can supply the vitalizing force to stir the peoples of the world into triumphant action, not only against their human oppressors but also against their ancient enemies, hunger, misery and despair."



The part of the underdeveloped world that received aid in 1954, commonly called Point Four. ***Foreign Operations Administration***

terials to raise the American and Canadian standards of consumption and provide a surplus.

In most of the countries of northwestern Europe the same general conditions exist but on a much slimmer base of raw materials. The United States and western Europe are prepared to produce machines to mechanize many other countries. The Point Four staffs have set out to show how Western ways may be introduced quickly into many lands (Fig. 6). If we consider the number of people engaged or the amount of money expended, this is probably the biggest educational enterprise on the planet, unless it be the drilling of its largest army.

If the Point Four technicians, or the rest of us who stay at home, would understand a country and its prospects for its future, we must consider all the factors. Certainly the Point Four technician must know them before he sets out to help other peoples with machines, sprays, seeds, and "know-how."

5. CAPITAL IS NEEDED TO IMPROVE ECONOMIC STATUS

What is capital? When a farmer begins, he needs land, horses or donkeys or oxen or tractors, plows, combines, hay balers, cows or cattle or sheep, feed, fodder, seeds, and other equipment.

The manufacturer who begins needs a building, machines, raw material, a market for his product, and money in the bank to pay wages before sales begin.

How did the United States get started? How did we get capital? There are two ways to get capital. One is to put your money in the savings bank and accumulate; the other is to borrow from those who have. The United States was built up largely by European investments in this country. We would be in a vastly different economic plight today if generations of British investors had not put their money into American enterprises of almost every kind from coal mines to cattle ranches and textile mills. The European immigrant came. European money bought his ship ticket to New York, his railway ticket to Pittsburgh, Chicago, or Minnesota. The railroad company or lumber company or steel company for which he worked got European money directly or indirectly to pay his wages and buy his food and tools.

When the Spanish-American War broke out in 1898, the Infanta (royal princess) of Spain owned a nice block of American Steel & Wire Co. stock. Spain was industrially dormant, a poor place to invest. Her money

helped *American* industry to grow. A book full of examples might be cited. We had resources; investments were politically safe; men and money came. Both prospered. We have now reached the point where we have money to lend—that is, to invest—at home or abroad.

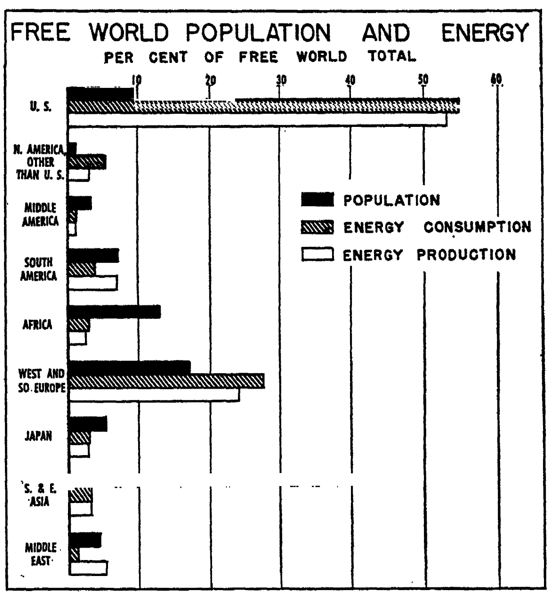
Capital comes from saving. Research workers for the Twentieth Century Fund say that an economically advancing society must save 12% to 15% of the annual product, and invest it, and that it takes $12,000 of capital to employ one operative. In 1953, $75,000 of equipment *per worker* was going into the new Fairless steel plant on the Delaware above Philadelphia. The American people were able to live well and produce the capital needed for hundreds of new factories in that year and since. The developed countries have capital. That is one thing that made them be developed countries.

The man with little land. Can the peasant farmer with a small patch of land save 12% to 15% of income, get capital, and lift himself? Let us consider the Near East, an area now much in the public eye and likely to continue to be so. Investigators, including some who work for the United Nations, are generally agreed that peoples of the Near East are almost hopelessly under the heel of the landlord. In these societies real estate, gold, and jewels are almost the only investments. The land collects in the hands of the strong, who became landlords. Society is composed of hordes of very poor tenants and a small number of startlingly rich landlords, who may live in the cities or even in foreign lands. Farouk, late king of Egypt, now exiled, still young, is reputed to have a fortune of $50 million. His father, who began with nothing, amassed land. Oriental kingship appears to be Big Business.

It is repeatedly stated that those in power in the Near East show little desire for change. They have everything already. The have-nots want to improve their condition, but have no power. The scene is naturally ripe for any agitator, especially for communist propaganda which, before it wins control, promises to give the worker the land he cultivates. In some of the Native states of India the Rajahs owned *all* the land.

In 1952 the government of India bought large estates and resold the land, 6⅔ acres per family, with many years to pay. If the owners of these little tracts ever pay for the land, the tract is too small for modern farm machinery. And further, at present rates of population growth there will soon be another generation of children, perhaps before the land is paid for. They must then subdivide or move. Whither?

What could the Point Four team do for that Indian peasant farmer? Farm machinery is not for him. He has no money to buy, no land on which to use machinery. He could not use it if we gave it to him. The American farmer who uses a tractor works 50, 100, 200, 300 acres or more. He has 30 to 50 acres per person. Our Indian farmer, with his government-aided farm, has perhaps an acre of land or a little more per person of the household. But



Examine the ratio between population and energy consumed and you see one explanation of wage rates in different areas. *Energy production* includes export of fuel. *President's Materials Policy Comm.: Resources for Freedom*

(Left) **The man of Pakistan carries feed for his cow.** ***J. Russell Smith. (Right)*** **The man of Colorado carries feed for his cow. The truck is a bit of** ***capital. International Harvester Co.***

his farm is larger than scores of millions of farms in Asia, and also of some in all the other continents. He is a type, typical of tens of millions.

6. DIFFICULTIES IN GETTING FOREIGN CAPITAL

The people of underdeveloped countries need capital. Usually they cannot or will not save. Can they get aid from the foreign investor? Can they borrow foreign capital as we in the United States did?

Consider a town in India, Pakistan, Iran, or Egypt. In this town labor is plentiful. Men work now for 75¢ a day or less. Town and environs are a good place to sell some product you know how to make. You have "know-how"; you have the capital needed to start production. Would you invest money there to establish your enterprise?

Iran and Egypt give the capitalists a lesson. In the new atmosphere of greater independence of small nations, Iran and Egypt have given capitalists two instructive lessons about the risks of foreign investment. For many months the Iranian government and the Anglo-Iranian Oil Co. quarreled about the terms of an oil concession that had been operative for decades and still had many years to run.

In 1951 Iran settled the matter unilaterally. It "nationalized" a $1500-million British oil enterprise—that is to say, the government of Iran took the largest oil refinery in the world without paying or having a plan for paying.

For three years the oil refinery stood idle. The Iranians could not run the refinery, nor would they let anyone else run it. Under the new international etiquette of respect for national sovereignty Iran said this is a local question and not the business of any other nation.[8] For three years the oil company and the Iranian government negotiated (or quarreled).

It would appear that the Iranian oil nationalization encouraged Egyptian malcontents, for shortly thereafter Egypt abrogated its Suez Canal treaty with Britain and threatened to take the Suez Canal by force in violation of the treaty—and also take shops and installations of a vast military establishment that cost $500 million and employed 70,000 Egyptians. After much threatening and inflammatory talk and some rioting, mobs in Cairo had a burning day. And the government did not disturb the mob while it burned buildings and millions of dollars worth of other property of the British, French, and other foreigners.

It appears likely that before U. S. or European capitalists will start important industries

[8] For the ending of nationalization, see page 320.

in many underdeveloped independent countries, they will consider not only the resources and the possible market but also the national psychology and the policies that may be produced by nationalism combined with ignorance, poverty, the radio, and native and foreign agitators playing upon local prejudices. The Age of Machinery has created new possibilities of wealth, health, and comfort, but they work more slowly than the new agencies of ferment and the new incitements to revolution among peoples who need revolution but may not know how to get it or keep it or use it.[4] This is a rich field for the Russian secret agent.

The lack of safety for the dollar, pound, franc, or guilder is the chief reason why so much of the world is yet underdeveloped.[5]

The desire for independence by the people of developed or underdeveloped countries is perfectly natural. But do not let yourself forget that independence in any country, including our own, means rule by a small group of people. The real questions are how do they get power; how do they use power; and how do they lose it? Can an honest election put them out? Can they give good government if they have the chance?

The fact that the Philippines, Indonesia, India, Burma, Ceylon, and Pakistan have passed from colonial status to complete independence has made trouble a-plenty for those countries that wish to continue colonialism. The change also presents the newly freed with many problems that would be difficult in countries with as much education and political experience as Great Britain, Scandinavia, or the United States. It will interest you to follow their experiences in the news of the years ahead. And there is likely to be much news.

7. INDEPENDENCE, TURKISH STYLE

Turkey has been through a most interesting and instructive experience. For centuries a wide empire of many peoples from Russia to Gibraltar, she came out of World War I reduced to the peninsula of Asia Minor and a little corner of Europe around Constantinople, which the Turks patriotically renamed. In their hot desire for independence the Turks removed the capital from the old metropolis of the straits to the semiarid interior, where they built a raw new town for the capital of the revived nation. The Turks feared Europe. They feared foreign power. They would use no foreign money. Foreign capitalists might bring European imperialism. The new Turks would be free. No foreign capital! Thus the new republic started in 1920. The absence of capital is a stark reality. It bites.

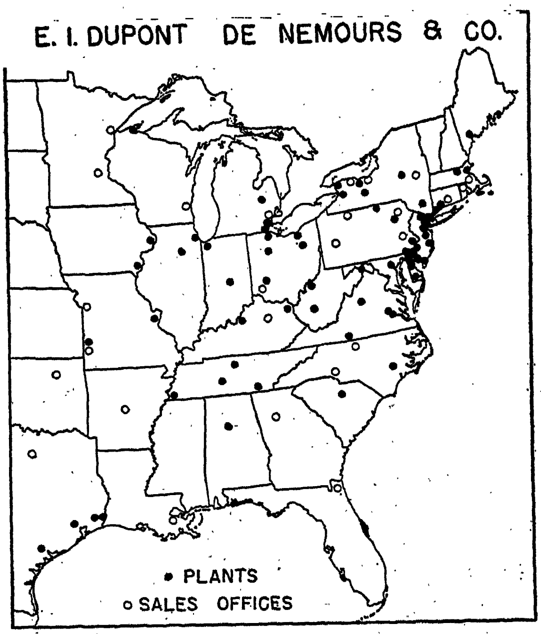
Local capital could not be found. The people had to make some things, so the government began to build and run industries. Thirty years passed. Costs of production in government factories caused financial loss. Then came bewilderment and the idea that something *must* be done. An election threw out the administration, but what could the victors do with the factories? Continued operation produced continued unhappiness.

They called a foreign doctor—the International Bank for Reconstruction and Development at Washington. Thirteen American experts visited and studied Turkey. They gave 276 pages of diagnosis and prescription. (See *The Economy of Turkey*, 1951, Johns Hopkins University Press.)

Manufacturing needs a psychological base, no matter what race tries it. A point this report makes clear is the psychological

[4] Robert C. Doty, *The New York Times Magazine*, September 19, 1954, page 65, article, "Egypt's Strong Man," tells of the patriotism and selfless honesty of Colonel Nasser. Nasser is the real ruler of Egypt, after a bloodless revolution that threw out a corrupt administration. Says Doty, "Blueprints for programs of industrialization, agricultural diversification and public works have been drawn up, but neither public or private capital, foreign or domestic has been forthcoming to support them." Now if poor but patriotic Nasser just had the cash value of the millions of foreign property that went up in that gleeful burning day 3 years ago! Very very expensive bonfires!

[5] British companies built, owned, and operated railroads in Argentina. A good student paper may illustrate this point by reporting the effect of Dictator Peron's government on Argentine industry 1945–1955 or later.



An American succeeds. Du Pont's staff of experts knows how to produce something and to keep accounts so that they know what they are doing. After a few decades they start another plant and another and another. E. I. du Pont started making gunpowder about 150 years ago and now their chemical and other products are legion. They have 12 plants in the West not shown on this map.

Who owns Du Pont? One of the authors of this book owns about a millionth part of it. He owns a few shares. He is one of nearly 200,000 stockholders, located in 48 states and 24 foreign countries.

unpreparedness of the Turks. Farmers who sow and reap within a twelvemonth, shepherds whose flocks double in a year, and merchants who do small business for large percent of profits are psychologically unprepared to think of amortization for a factory building and operating it for a profit of 8% or 10%. This is more or less true of almost any strictly agricultural population in any continent including parts of the United States.

Now back to Turkey! An American long resident in Turkey was well acquainted in a Turkish town where an electric-light plant, driven by a rickety gasoline engine, charged 18¢ per kilowatt hour. "Why don't you get together and build a good plant?" said the American. "There's a good waterfall out there." They talked and talked and verbally sparred for an hour. Then at last one of them spoke frankly, "Mr. Jones," he said, "we can't. We don't trust one another." The lack of common honesty is one of the main causes of underdevelopment.

The new Turkish government faced the facts. It admitted its inability to proceed. It reversed its old policy and invited foreigners to come and start industries. In 1954 the President of Turkey crossed the ocean, toured the United States, and repeated in person the invitation for foreign capital. He also made it clear that the foreign investor could send his profits and his capital home if he wished. (In Brazil it is difficult for a foreign factory owner to send profits home.)

We have given these accounts of Egypt, Iran, and Turkey because they show clearly why those countries and many others are "underdeveloped." The example of Turkey shows that a nation may learn quickly and take steps that move the country toward the developed group. Turkey is a most heartening example. It is more than likely that in a short time there will be scores, possibly even hundreds of Dutch, Swiss, German, British, Swedish, and a few American experts in Turkey in positions of counsel and management. Two or three of these men in a factory will be teaching 20 or 30 the elements of business that people of the West have taken generations to work out. The example of a rejuvenated and prosperous Turkey may stir other peoples.

8. POLITICAL ASPECTS OF ECONOMIC DEVELOPMENT IN LATIN AMERICA

We hear much concerning the opportunities awaiting the touch of American "know-how" and American capital in Latin America, but political conditions must be considered. Nearly every Latin American country has an army—sometimes a surprisingly large one in relation to the resources and population of the country.

These armies are primarily for the purpose of protecting the current governmental regime

The New York Stock Exchange. Several hundred corporations are big enough to have stock sold to many owners. If they publish reports of sufficient accuracy, their stock may be listed by the New York Exchange and sold and bought on its floor. You go to your bank, tell the banker to buy 20 shares Common of XYZ Co. He trusts you to pay for it, and tells his broker in New York to buy. The broker trusts the bank to pay. Broker buys the stock, pays for it. The banker pays the broker, and gets the stock. You pay the banker, get the stock, and become part owner of an enterprise which you trust enough to give to the management the care of your money.

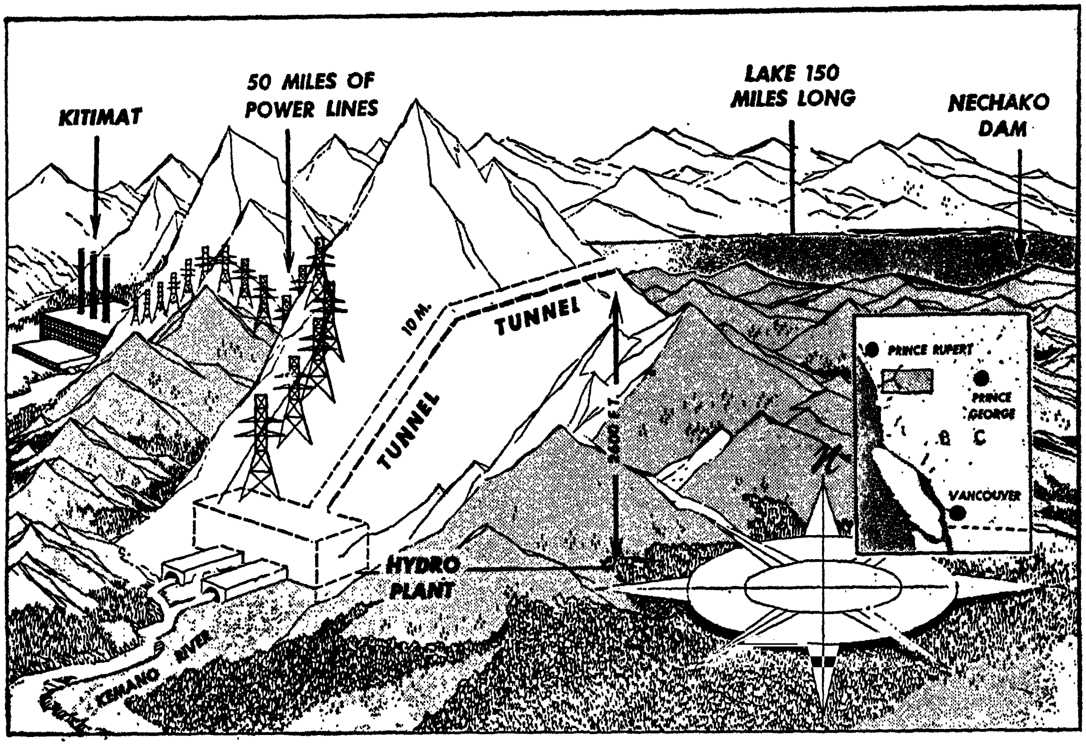
The Pennsylvania Railroad Co. has about as many stockholders as Du Pont. Dozens of other corporations likewise.

If you should buy 10 shares of stock in Sears, Roebuck & Co. you would be one of 96,735 owners located in 48 states and 34 foreign countries. You would own a part of 11 mail-order plants, scattered—Boston, Atlanta, Los Angeles, Seattle; 694 U. S. retail stores and 24 foreign; 20,600,000 square feet of retail floor space. You could perhaps stretch a point and say that you were in big business because "your" company has 167,484 U. S. employees and 5488 foreign, had sales of $2,981,925,186 in 1953. Your general catalogue has in it 107,118 items.

This is a staggering monument to the fact that, in the United States, people can trust each other in money matters to a substantial extent and can do business accordingly. Therefore we are not underdeveloped (see Fig. 12). Thousands of scattered strangers combine $ millions to own this.

against rebellion which, if successful, would place a rival general in the presidential palace. Real elections are rather rare, but Latin American "elections" by military shift, with or without a little fighting, is almost standard in many countries. Venezuela, for example, has had 22 constitutions and one election in 125 years. The one elected regime was soon thrown out by military force. Three of these military winners were soon shot from ambush.

Teach democracy? Much mischief has been done by spreading about the world the idea that democracy is a cure-all, either political or economic, that any country can introduce it simply, somewhat as they would introduce steam heat or electric fans. "Just give the people a vote and they will be free." The United States occupation forces have done some really ludicrous things in attempting to start democracy in Japan and elsewhere.



In western British Columbia engineers discovered on the headwaters of the Fraser river an area of plateau dotted with lakes. They went to work, and now a big dam holds back all the water that falls on 5700 square miles of rainy upland dotted with lakes. The reservoir covers 350 square miles. A tunnel 10 miles long carries water under the mountains and lets it fall 2600 feet to sea level. Our picture here is somewhat like a token; it has no scale. Note the figures. The power plant to produce 1,120,000 h.p. is entirely under ground. Ultimate capacity, 1,670,000 h.p.

The shores are so steep that they had to build a power line 50 miles long over the mountains to find room enough for a town—Kitimat—to use the power for electric smelting and pulp making at the head of a fiord where ships could serve. *Aluminum Company of Canada*

Democracy is in reality a rare plant, exacting as to its environment and needs, and withal difficult to grow.

The illustrious James Bryce has explained that unpleasant idea in his book, *South America, Observations and Impressions* (The Macmillan Co., 1918, Ch. XV), in which he lays down or recounts the conditions affecting democratic government:

(1) Physical and geographic conditions should permit easy communication, travel, and acquaintance for the formation of opinion and operation of government. Most Latin American countries have scattered communities isolated by mountains, jungle, and distance.

(2) There should be racial uniformity to permit understanding and sense of community. Only Argentina and Uruguay are all European. Others are mixed Spanish, Indian, Mestizo, sometimes Negro and Mulatto.

(3) There should be economic and social conditions that produce a middle class that can profit by good government and form public opinion to bring it to pass. Most countries have vast estates, tracing back to royal grants; little or no middle class; and high illiteracy.

(4) Historical conditions of colonial period have much influence on the present. English colonies got democratic experience ruling themselves, almost. Spanish colonies were ruled by the viceroy and the captain-general.

(5) Latin American independence by revolt left power in the hands of generals—which general? Often there were several and they fought to decide who should rule. Parties became factions that followed this or that

leader. Results varied. In the words of Bryce, "Some are true republics in the European sense . . . others are petty despotisms maintained by force, . . . not governments deriving their just powers from the consent of the governed."

Examine Latin America carefully in *Goode's World Atlas* (Rand McNally & Company). Note topography, railways, towns. Appraise for yourself the possibilities of democracy. Bryce's ideas and Goode's atlas explain much about the troubles of Latin American governments. (See railway map, Chapter 33.)

The men in the presidential palaces of many countries in Latin America and elsewhere in the independent undeveloped areas are not responsible to an informed electorate that can hold a free and an honest election and then change their government. It is not uncommon for political (often revolutionary) opponents to be kept in Latin American prisons for months and years without trial.

The "President" usually comes to power by palace coup, with perhaps a bit of fighting, and he usually lives in fear of going out by the same process. In some countries serving a stated period, quitting at the end of it, is unusual. For the first time in 25 years, an Ecuadorian president recently finished his term. These governments resemble the government at Washington by copying our constitution and using the names "president," "congress," "court," but supreme courts are sometimes dismissed like a class of school boys. Election by force and government by dictator are very troublesome facts for those who consider starting industry and raising standards of consumption in the coming decades in Latin America.[6]

9. CAPITAL IS WAITING

The developed lands are ready to help. We have explained how North European capital helped to build up the United States and Canada. Almost any one of half a hundred underdeveloped countries would start on an industrial boom almost instantly, if the financiers of New York, London, Paris, and Amsterdam could be sure that their capital would be as safe in these foreign countries as in their home countries or in Canada. It would be a double boom, a second one in the developed country that supplied the capital.

In a period of less than three years, 1950–52, $1400 million of American money was invested in Canada. In the same period $100 million was invested in Brazil. Both Brazil and Canada are larger than the United States. Both are rich in undeveloped resources. Canada has 14 million people, Brazil has 52 million.

Capital can run away or hide. The people of a country have to endure their government, but capital is more mobile. It runs away or hides. We were speaking with an educated Hindu about the shortage of capital. "They have capital," said he (meaning money). "And," making a gesture of digging, he said "They bury it." When famine or turmoil comes, the gold and jewels are still good. What about your factory, your salable goods, your stocks, your bonds, your cattle?

In countries where capital is not safe as few industries as possible are opened instead of as many as possible. A great gulf separates these two.

The London Economist, June 2, 1952, stated the problem of foreign investment thus: "This seemingly economic problem, in fact, like many others, is really a political one. Where the political conditions are favorable, then capital investment can usefully proceed: where no, not." Many political problems are actually moral and spiritual.

---

[6] Here are two facts of industrial significance. Many more might be cited. Mexican government 50-year $1000 bonds @ 5.69% were issued in 1904 in the golden days of Dictator Diaz. Price 1942: $206.19. Revalued at that figure and postponed with promise to pay January 1, 1968. Market price 1954: $96.01.

The United Fruit Company owned 150,000 acres of banana land in Guatemala. The government of Guatemala took it and offered in payment bonds payable in 25 years—time enough for 1 or 2 or 3 revolutions.

10. WHAT IS THE PROSPECT FOR IMPROVED PRODUCTION IN UNDERDEVELOPED COUNTRIES IN THE DECADES IMMEDIATELY AHEAD?

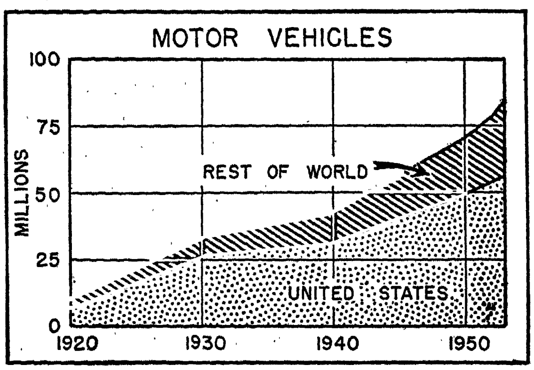
In the *Christian Science Monitor,* May 13, 1952, William Frye, writing about the U. N. Preliminary Report on the world social situation, said, "Roughly two thirds of the world's population is fighting a losing battle against poverty, hunger, and ignorance while the other third is making dramatic strides toward better living . . . one of the most significant developments of the 20th century."

This report calls attention to "6% less food available now than there was before World War II, and many, many more people to feed." The U. N. experts say that the peasants of Asia, Africa, and South America are "the forgotten men of the century." The U. N. experts say that greater international cooperation is needed to solve problems *"that appear insoluble when viewed within the frame of national resources."* Here is a plain call for help. International help. Help for the helpless. Between 1952 and 1954 there has been almost no reversal of the above reported food conditions of 1952.

Can we expect quick changes? During the continuance of low standards of business morality and governmental morality that now exist in many underdeveloped countries, investment of foreign capital in such countries apparently must continue to be, as now—limited to the lowest possible figure. That means industry limited to very simple manufactures, the extraction of crude raw materials, especially oil and ores, and agricultural products that can be kept for months and do not require far-reaching organization for processing or shipment. Bananas as grown in Middle America may be cited as a partial exception to this rule. (See Chapter 9.)

Except where business safety prevails, merchants (often foreigners) in the ports will continue to handle wheat, corn, sisal, abaca, palm oil, palm nuts, copra, peanuts, coffee, cacao, hides, wool, cotton, rubber, jute, woods, and some fruits and vegetables. These products can be produced by units operated by native populations and without the aid of large capital investment from any source. The relation of banana companies to government would make an interesting study, especially if you could get the facts.

There is possibility of increased government enterprise if governments can borrow or have money given to them or take it in taxes. Remember Turkey! But also remember Egypt!



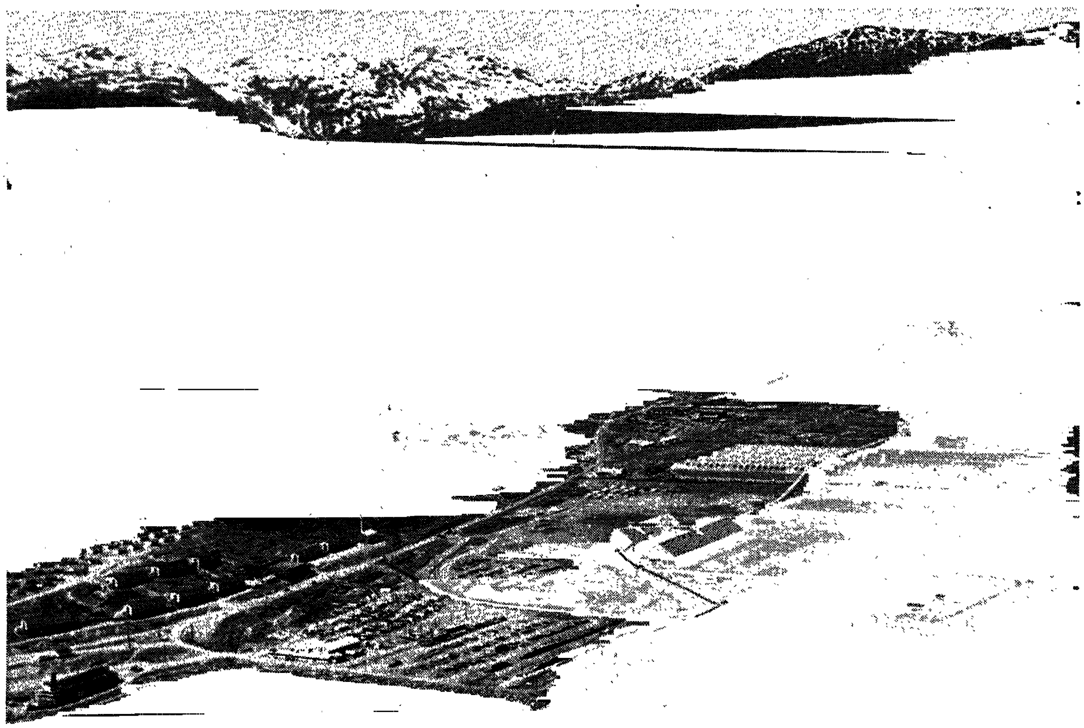
Another way of showing the two worlds. Add Europe to United States and what remains for the other six sevenths of the world? Data from American Automobile Manufacturers Association

11. THE TWO WORLDS AND THE NUMBER 1 WORLD PROBLEM

In one sense we have one world, the world of world trade. As we settle into the postwar world we realize that it has divided itself naturally into two worlds, the developed and the underdeveloped. A great chasm separates the two worlds. The chasm between them has widened since World War II. Can it be narrowed? That is the Number 1 problem of humanity.

12. WHAT CAN BE DONE ABOUT IT?

Can we spread more news? We have shown that the underdeveloped countries do not have capital but need it. The developed countries have capital and would be glad to invest it in the underdeveloped countries, but the risk is too great until the people know more and



Town site of Kitimat. Who owns all this Kitimat enterprise 200 miles long? Perhaps many of the readers of this book have a microscopic share. The Aluminum Company of Canada is a subsidiary of Aluminum, Ltd. There are several kinds of securities. They are widely held in the United States, Canada, and other countries. Some of these securities are held by banks and insurance companies. By way of an insurance company, thousands have a micro-interest but do not know it. The total is possibly scores of millions.

This, the biggest privately owned power enterprise in the world, is a type product of Western civilization and also one of its typical physical bases. ***Aluminum Company of Canada***

think differently. That's all. It is a problem of education.

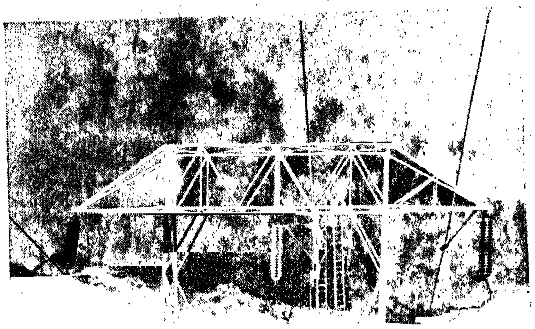
We have shown that millions of people in the underdeveloped areas of the world have been getting information rapidly by means of the new communications. New facts rouse new desires and tend to make political ferment. People in ferment tend to make trouble. We cannot stop the ferment. We cannot shut off the sources of information or misinformation. The great need of these people is for more and better information. The new means of communication that have been the basis of propaganda's ferment should now be put to work in a big way and used for a wide campaign of mass education.

This radio that rouses mobs may also be used to carry useful information to educate. But first those who hear must know whom they can believe and who is giving misleading propaganda. Let the people know that at some stated hour they can assemble at the village radio and hear some music and a success story that they can believe about the achievements of some people much like themselves—how to keep the little chickens from dying, the virtues of a new kind of cabbage, how the people on the other side of the mountain have a cooperative to sell eggs, and so on, week after week—adult education.

Whom can the villagers believe? That's the rub. The radio is often the greatest lie factory that man ever dreamed of in the age of fable! But there are already two agencies in the international field for telling the truth—Point Four and the United Nations.

The U. N. is young. It has but little money, as yet, but any day now the world may discover that here is the great Neutral Power that people can trust in an age of propaganda. Can the U. N. carry the torch and let light into dark corners? The U. N. Technical Assistance Program is doing essentially the same thing that Point Four sets out to do. It is financially weak, but it should be able to establish the fact that it tells the truth in an age when lying has become a high art.

The capital for underdeveloped countries belongs to persons, banks, and other business corporations that are organized for financial profit.



Here's a job for you. Build a power line 50 miles long up this gulch and over the mountain pass more than a mile high and covered with 20 feet of snow—a helicopter job. Note the men. ***Aluminum Company of Canada***

The U. N. is more like the Red Cross, an example of the nonprofit type of organization. The world has a host of educational and missionary ventures from many lands. These are definitely planned to give service without cash profit, but most of them are a bit suspect. They are organized to promote some group, some church, some definite idea.

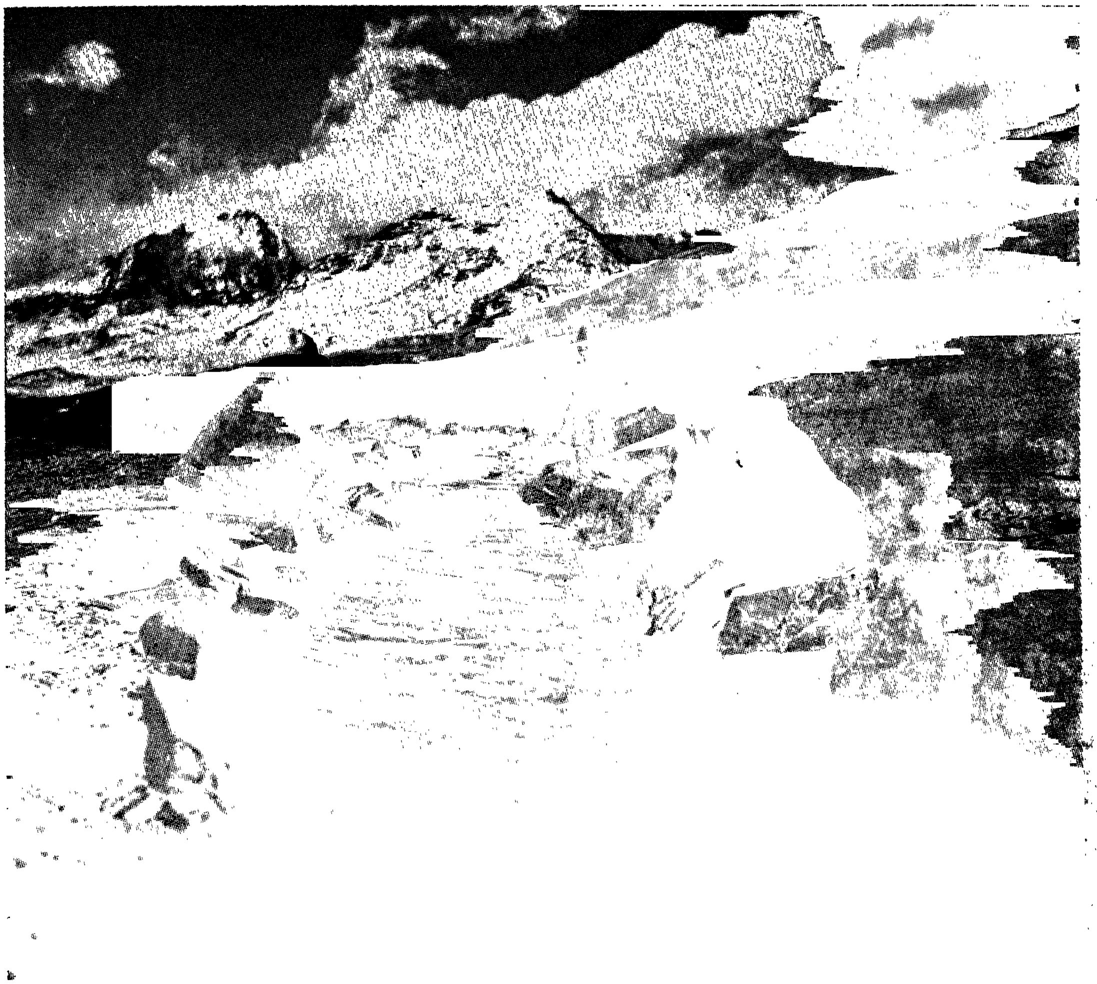
The U. N. is ahead of Point Four and the missionaries in possible neutrality. Suppose the U. N. had the money to start small local demonstrations of neighborhood reconstruction. This might include crop-growing, cattle-keeping, human nutrition, public sanitation, and, where possible, instruction in the simplest manufacturing, probably starting with canning and drying surplus foods. It would be easy to have a sending radio and plant a receiving radio in each of a number of surrounding villages.

When this neighborhood work had proved itself with better chickens, better beans, better kitchens, better wheat or corn or clover, the U. N. center could have a small bus and bring in by invitation selected persons from neighborhoods for miles around. The next stage would be organized excursions of selected visitors from distant but similar localities in homeland and neighboring countries. Such sample localities have one secret weapon that has fairly easy penetration for the dictator's armor. The dictator always needs money and he may give surprising immunity to these U. N. demonstration communities if they are paying more tax than the neighbors. And they can easily do this because the U. N. Technical Assistance Program can make great percentage improvement almost anywhere that the people are willing to help—and many of them are willing. The Iranian people were welcoming U. S. Point Four workers in the provinces even in the hot days of the oil dispute, when mobs in the streets of Tehran were marching about shouting antiforeign slogans outside the house of parliament. "Yankees go home."

The greatest advantage of the U. N. is the possibility that it may be neutral and be believed to be neutral. With this great advantage and adequate support it may become in a short time a great world force that is really promoting better industry and better living alike for Christian, Buddhist, Moslem, Jew, Shinto, or ancestor worshiper; democrat or totalitarian; white, black, yellow, brown, or red.

We have done big things in industry. We have done even bigger things in war. It is time we seriously planned to do big things in the war against ignorance.

The young United Nations is getting experience and gathering information. It is the one thing in the world that is in best position to tackle the problem. Will the developed countries have the courage to equip and push it? It really would be good business. And it might end war. The United Nations is the greatest of all our underdeveloped resources.



The Bolivian Plateau: so high and cold that trees do not grow. Population, chiefly Indian; shepherds with a patch of land subsist on potatoes, a grain called quinoa, sheep and llama; dried dung domestic fuel. Heavy wool wraps, probably homespun, tell temperature of the water in which these Indian women wash clothes.

U. N. is trying to help. Needs more money, a lot more. ***U. N. photo***

2· The Role of Animate and Inanimate Energy

1. HUMAN ENERGY AND PROGRESS

Prehistoric farmers: the founders of civilization. From time to time the archeologist digs up bones and stones and other relics and records of antiquity. All evidence points to the fact that from earliest times environment has been a mighty molder of civilization. Long before the dawn of history, the protection offered by a sheltered site and the beckoning fertility of a moistened valley lured nomadic man to cease his wanderings and turn to tillage of the soil.

It was no mere accident that some of the oldest civilizations of antiquity had their origin in river valleys. In such valleys as those of the Nile, Euphrates, and Indus, natural barriers of the desert and thin pasture gave some protection against invaders. Here man found rich alluvial soil annually watered by the overflow of the river and refertilized by the deposition of silt. Here man made the first large-scale conquest of nature. Native vegetation gave way to man-chosen crops, and in time natural inundation was augmented by irrigation through man-built ditches. More and more cultural features were added to the natural landscape. Here, in a fixed abode, community life developed. The repeated experience of a sedentary life gave rise to great material and cultural progress. These prehistoric farmers may be regarded as the founders of civilization and the teachers of the human race.

This shift to a sedentary life was a great step in human progress. The energy of man and beast was applied to the growing of crops, which involved the large-scale use of the energies of sun, water, and soil. Nothing so changed man's way of life until the coming of the Machine Age many centuries later, when man tapped the buried energy of the fossil fuels. We shall see that energy is in many ways the keystone of progress.

Limited progress in lands of tropic abundance. Throughout the long reach of human time, no environmental factor has had a more persistent influence upon human progress than climate.[1] Perhaps it may be said that civilization is the product of moderate climatic adversity. For races as for men it seems debilitating to be born with a silver spoon in the mouth. The great civilizations of all times seem to have arisen where nature made production possible only a part of the year, and thus made it necessary for man to work and

[1] According to Huntington, climate, racial inheritance, and cultural development are the three great factors determining the conditions of civilization, and all three must rise to a high level if a race is to reach the highest plane of civilization. Ellsworth Huntington, *Civilization and Climate,* Yale University Press, New Haven, 1935, p. 387.

save up for the time when he could not produce.

Man does not naturally like to work steadily, and if nature enables him to avoid it, he usually seems content to loaf rather than labor, save, and progress.

The thing we call civilization seems to begin with the accumulation of a *surplus.* Man's elemental wants are easily met in the humid tropics, where the vegetation is always green and growing. Unfortunately, there are many diseases, and the climate is so humid and enervating that man does not get the habit of continuous work or become ambitious. He has neither the need nor the desire to accumulate a surplus. Accordingly, no great civilization has arisen in the warm, moist tropic areas.

The native of the West Indies, tropic Africa, the Amazon Basin, or the South Sea islands, or any other part of the humid tropics can build himself a little shelter of palm leaves or grass to keep off the rain; the warm climate removes the need of further shelter or many clothes. A few banana plants by the hut and a little patch of sweet potatoes will live and yield for years, for there is no frost to kill the plants. Cassava, beans, peanuts, and other vegetables grow easily. The forest yields nuts, wild fruit, and game; the streams are alive with fish. Wood in abundance supplies the little fuel he needs for cooking, and if he would make himself a drum or any other simple luxury, the raw materials of the forest lie at his hand in great abundance and variety. Accordingly, the native of these regions may work his yearly round of hunting and gardening and live the hand-to-mouth existence, as, for untold generations, his ancestors have done before him—organizing only the small and primitive village community. In the steaming tropics human energy is at its lowest ebb. The weather leads to sitting and dozing, and the tropic forest does not encourage large human groups and organizations.

Limited progress amidst polar poverty. The polar and subpolar regions are in contrast to the natural productivity of the tropics. The rigors of climate place a heavy premium on human skill and energy. On bleak tundra and Arctic islands the Eskimo spends most of his time hunting and fishing, and he must work long, hard, and cleverly. The Eskimo has never studied the modern military science of camouflage, but he knows how to fool the wary seal basking at the water's edge. Clad in a white bearskin, he crawls inch by inch across the ice, making a seallike scratching noise with an implement that has claws, finally grabs a flipper, and drives his knife home. He has never heard of Archimedes' flame throwers or seen a modern airplane catapult in action, but he knows how to launch his little boat, the kayak, when the surf is rough. His companions will swing him, boat and all, like a pendulum and let fly at a given signal, thereby launching man and boat clear of the breaking waves. He sits in the boat with the end of his outer shirt, made of water-tight seal gut, tied tightly around the boat's small opening; hence no water can enter. If the boat upsets, he can right the boat and paddle safely onward.

In order to exist, the Eskimo makes use of every available resource, and no white man has ever improved upon his devices if using only his resources. He lives in a hut of stone and sod, or sometimes an igloo of snow or ice, heated by the flame of a seal-oil lamp with a wick of tundra moss. When he ventures forth into the dazzling glare of Arctic ice, his eyes are protected by shatterproof goggles made out of walrus bone with narrow slits that suffice for seeing. The bones of the mighty walrus provide the frame for his little kayak or larger umiak, the frame for his dog sled, and material for making needles and other tools. Skins of seal, caribou, or bear make warm clothing. Seal, fish, walrus, and bear are main elements of his food supply. In the long days of Arctic summer he may make a trip inland to hunt caribou and musk ox, to catch migratory waterfowl, to collect birds' eggs, and to pick berries that may be preserved by drying for winter use. In the more favorable location along the west coast of southern Greenland, he may stay at home, cultivate a patch of vegetables, and catch fish for the Danish cannery.

The Eskimo's struggle with nature is a continuous performance, and his economy with its caches of meat for winter food is of a vastly different kind from that of the hunter or gardener in the tropic forest. The meager resources of polar and subpolar regions can support only a sparse population. Indeed, all the Eskimos of North America would not fill half the seats in a modern sports amphitheater. In these lands of severe climatic handicaps, no great civilization has arisen, and none will.

The stimulus of moderate climatic adversity. Between the extremes of tropic abundance and polar poverty are intermediate regions where nature imposes upon man a moderate amount of climatic adversity, but also gives him a chance. In some regions the growth of crops is halted by the coming of frost and winter; in others, by the coming of the dry season. Here man must produce enough food and save enough during the season of plenty in order that he may live during the season of scarcity. Hence, the regular coming of a nonproductive season forces upon man the habits of work and thrift. He must lay aside something for the future. This habit of saving leads to the accumulation of wealth, and wealth tends to make a nation and its people powerful, whether they be ancient, medieval, or modern.

Among the first great civilizations of antiquity, as we have seen, were those that had their origin in the valleys of the Euphrates and the Nile, where a fertile soil and a seasonal moisture supply produced by an annual overflow made great crops followed by blistering drought.

The need of a surplus of food to last through the dry season naturally produced the habit of working and saving, and resulted in a sufficient surplus of goods to support life and to allow man the leisure time to develop culture, arts, and the things we call civilization.[2] Thus, Babylon, Nineveh, and Thebes were rich and cultured cities at a time when all Europe lay in barbarism, and the pyramids were built many centuries before the drought-driven brethren of Joseph went down to Egypt.

It is within the lands of the temperate zone, however, where fruitful harvest is followed by the stimulus of frost, that we find the best conditions for the development of energetic races. Here the coming of winter's frost and snow brings death or hibernation to the entire vegetable kingdom and drives man to the protection of heated buildings and warm clothing. Man must work and save and plan for the winter; otherwise, he faces hardship and starvation.

Here, too, under conditions that are not too hot and not too cold, frequent changes in the weather spur man on to his greatest physical and mental activity. The rise of modern civilization and the development of the greatest centers of world power in the temperate lands of the North Atlantic Basin are due to a number of outstanding causes, but there can be no doubt that climate has played an enabling and a stimulating role (see maps showing the distribution of human energy and civilization, Figs. 50A and 50B).

The ideal climate for human progress. Temperature, humidity, and variability are of special importance in their influence upon human health and energy. As a result of years of research, the late Ellsworth Huntington, Yale's great climatic enthusiast, found that the conditions of an optimum climate are as follows.[3] (1) The average temperature in the coldest month should rarely fall below 38°F., which is the best temperature for mental activity, and in the warmest month it should not greatly exceed 64°, the optimum for physical activity. (2) Frequent storms, or winds traversing oceans or large lakes, should keep the relative humidity quite high, except in hot

[2] One of the commonest cycles of human history has been the conquest of the shore or valley farmer by the nomad. This is really a key to much of Eurasian history. See J. Russell Smith, "Grassland and Farmland as Factors in the Cyclical Development of Eurasian History," *Annals of the Association of American Geographers,* September 1943, pp. 135–161.

[3] See Huntington, *op. cit.,* pp. 220–239, and his *Principles of Human Geography,* John Wiley & Sons, New York, 1940, pp. 343–349.

weather, and should provide rainfall in all seasons of the year. (3) There should be a constant succession of cyclonic storms, or frequent breezes (as along the cool coast of California) that bring about frequent and moderate changes of temperature. These conditions are most conducive to human health and energy and make the ideal climate for large human achievement.

Huntington makes the following observations about regions with climates approaching the ideal for mental and physical activity:

No region on earth fully satisfies all the requirements. England and the neighboring parts of continental Europe come nearest to the ideal, but northern United States, a narrow strip close to the Pacific Coast from California to British Columbia, and finally New Zealand fall little if any behind. In [continental] Europe the chief limitation of the region within 400 miles or so of the North Sea is that changes of weather are not quite frequent and strong enough, and there are sometimes long periods of monotonous dampness. Southeastern England perhaps ranks highest in this region. Farther east, in Germany, the conditions are much like those of southern New England and New York except that changes are not quite so numerous or so extreme. The northern United States east of the Rocky Mountains has almost the right amount of storminess and humidity, but the summers are often too hot and the winters too cold, and the cold waves are too severe. The western coast of the United States, on the contrary, is almost ideal as to temperature and has a favorable degree of humidity most of the time, but does not have enough storms.

Although the Japanese climate cannot rival those of the regions mentioned in the last paragraph, it is excellent because of its very favorable temperature except in summer, its many storms, and abundant rain. The chief difficulty in the southern part, where most of the people live, is that the summers are too warm and especially too moist.

In the southern hemisphere, New Zealand has probably the best climate, for there are no extremes of temperature and storms are fairly abundant. The southeastern corner of Australia also has a fairly stimulating climate, as have parts of Argentina and Chile, but in these three regions cyclonic storms are not very numerous and hence there is not sufficient variability.[4]

Further support of the Huntington thesis is afforded by the achievements of the native Maori of New Zealand, the Araucanian Indians of southern Chile, and the natives of the corresponding latitude on the coast of Alaska. The Maori, magnificent specimens, are the only colored race that sits in any parliament in the British Empire on an absolute par with the British. The courageous Araucanians maintained their independence in the face of the Spaniard until the era of repeating rifles, and the late R. C. Brooks, Alaska specialist, claimed that the Indians of the coast of southern Alaska had the most highly developed native culture in North America.

Wherever you find a high degree of civilization, great productivity, and a high standard of consumption—or if the converse be found—the explanation must always lie in the *character of the people and the character of the environment* in which they live. Climate is merely one environmental factor in the equation of human development. Regions differ greatly in size, shape, location, land forms, bodies of water, soils, minerals, and native vegetation and animal life. The opportunities and obstacles of nature vary from place to place. How environment functions in the service of man depends not only upon what nature has to offer but also upon cultural or man-made environment, human wants, and human abilities.

Nothing ever happens without an expenditure of energy. Human progress depends upon the nature and extent of man's available supply of energy or capacity to do work. Brains, not brawn, is man's great asset. Man is forever seeking and finding ways to make brawn more effective in his daily life. Year by year, century by century, man's ability to utilize matter and energy has increased. Each new source of energy discovered by man has increased the effectiveness of his labor. Indeed, the advance

[4] Huntington, *Principles of Human Geography,* pp. 348–349.

An Indian porter on the streets of Mexico City. The human being may carry unbelievable burdens. *M. Ogden Phillips*

of civilization has been marked or produced by one improvement after another in the supply and use of energy.[5]

2. ANIMAL POWER

The importance of animate energy. Although man dominates the earth, he is physically weak in comparison with many animals. In prehistoric times man learned to use the superior strength of the ox, ass, and other animals to aid him in his daily work. It is generally conceded that man was not civilized in the Eastern Hemisphere until he had harnessed the energy of animals and had appropriated the physical and chemical energies of sun, water, and soil through agriculture. Indeed, it is one of the wonders of history that the ancient Aztec and Maya peoples were able to build temples and pyramids and to develop a remarkable civilization without the aid of any draft animal and that the Inca of the Andes was able to do likewise with only the aid of the little llama.

Many civilizations have been confronted by a shortage of power, causing man to harness the energy of his fellow men through the institution of slavery. Under conditions of slavery, free men were few, and human beasts of burden were many.

Although men of ancient civilizations made limited use of the inanimate energy provided by wind and running water, man's capacity to do work for more than 60 centuries continued to depend predominantly upon the muscles of man and beast. Even as late as 1900, one half the work in the United States was performed by horses, mules, oxen, and men.[6] While animate energy at present accounts for less than 8% of the world's total energy supply,[7] many millions of men remain dependent upon the humble and daily service rendered by draft animals, and some still depend on human muscle.

Draft animals of general distribution. Ten animals provide most of the animal power used by man. Five of them are of almost world-wide distribution, namely, the horse, the ass or donkey, the mule, ox, and dog. Five are of limited distribution: the reindeer, yak, llama, camel, and elephant. The usefulness of each type depends not only upon the distinctive characteristics of the animal but upon such factors as the cost of feed, the nature of the work to be done, and local climatic and topographic conditions.

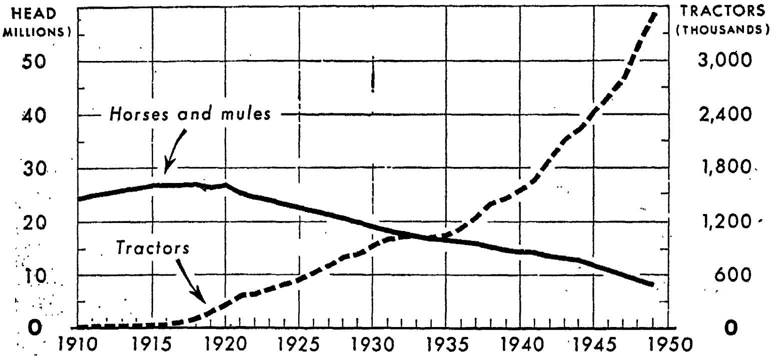
The horse is the aristocrat of draft animals and has been second only to the slow and sturdy ox in mass of work performed. He lives throughout the temperate zones except

[5] For a thorough presentation of the concept that history on its material side is the story of man's increasing control over energy, see James Fairgrieve, *Geography and World Power*, University of London Press, Ltd., London, 1932.

[6] Gloria Waldron and J. Frederick Dewhurst, *Power, Machines, and Plenty*, Public Affairs Committee, Inc., New York, 1948, p. 8.

[7] U. S. Department of State, *Energy Resources of the World*, Washington, 1949, p. 28.

HORSES AND MULES, AND TRACTORS ON FARMS, JANUARY 1, UNITED STATES, 1910-49



This graph shows how the iron beast of burden on U. S. farms is sending its zoological predecessor into limbo. *U. S. Department of Agriculture*

in the most extreme deserts. The horse does not do well in the humid parts of tropic and subtropic regions, chiefly because of the attacks of insects, and he is barred by tropic forests and the snow-covered North. The slender, agile, and spirited Arabian horse has long been known for its muscular force and ability to subsist on scanty feed and relatively little water. The largest and most powerful of all draft horses, however, have been produced in western Europe by scientific breeding, namely, the Belgian, the Percheron of France, and the Shire and Clydesdale of Great Britain.

In many lands the horse steadily gives way to the tractor and the motor truck. Today there are less than 65 million horses in the world, as compared with 96 millions in 1934–38. More than one half of all horses are now used in the Soviet Union, Argentina, Brazil, the United States, Mexico, and France.

The mule, which has a donkey for a father and a horse for a mother, is in some respects a better draft animal than either parent, but the sterile hybrid goes through life without pride of ancestry or hope of posterity. The donkey is noted for its extreme hardiness, longevity, and ability to thrive like the goat upon rough forage. It has larger bones and greater strength than a horse of similar size. The burdens borne by a donkey are almost unbelievable. From this parent the mule inherits long life, a hard small hoof, sure-footedness, stubbornness, and ability to thrive on little feed. From the horse it inherits both size and spirit. Unlike the horse, the mule stops eating when he has had enough.

The donkey and the mule prevail where conditions of life are hard. China alone has about one third of the world's donkeys. Ethiopia, Mexico, Turkey, Brazil, Iran, India, Egypt, and Spain account for about one half. Throughout the arid regions from Morocco to Peiping the donkey and mule climb the hills, thread the mountain passes, and browse on scanty vegetation in companionship with the camel that braves the worst desert, the plodding ox that draws the creaking cart, and the swift horse that bears the proud chieftain. From its arid plateaus Spain has long exported some of the world's finest donkeys to be used in the breeding of mules. About one half of the world's mules are used in Brazil, the United States, and China, the remainder being found in many lands. The ability of the mule to work longer without resting and to stand more humidity than the horse makes him a favorite draft animal in our southern states and in Brazil.

Oxen are used, to a slight extent at least, as work animals in nearly all cattle-keeping countries. The slowness of the ox makes him less efficient than the horse, mule, or donkey. On the other hand, the ox is stronger, he survives the torment of insects far better, and he will stand more abuse without injury. When deep in the mud, the ox will pull where a horse will not even try. Hence, the ox-drawn cart is commonly used in muddy sugar-cane fields and on almost impassable roads in the rainy tropics.

The work beasts of poverty pull the cart in Mexico as in a wide, wide area of the underdeveloped lands. Note wheel. *Ben Lemert*

In the main, the ox is the work beast of poverty. To the poor man, the fact that oxen will eventually be eaten is adequate proof of the superiority of the bovine over the equine genus. Many millions of people use no other beast of burden. In spite of his slowness, the ox remains of outstanding importance in southeastern Europe, in the humid parts of tropic Africa and America, and especially in the monsoon lands of southern and eastern Asia. On the muddy roads and in the wet rice fields of the Orient the carabao, or water buffalo, a zoologic cousin and economic duplicate of the ox, is a major beast of burden. India undoubtedly uses more oxen than all the rest of the world; its 193 million cattle are chiefly oxen and include about 45 million water buffaloes. You will see the carabao in Bulgaria, south China, and all nondesert lands between.

Historically, the ox and work cow far outrank the horse in importance. Their tough necks and shoulders can stand the barbarous-looking yoke. The horse cannot. The bovines had several millennia of service before the horse collar was invented. A dubious service of the horse has been as destroyer of civilizations—cavalry.[8] The bovines in the yoke may almost be said to have emancipated man from the hoe and civilized him.

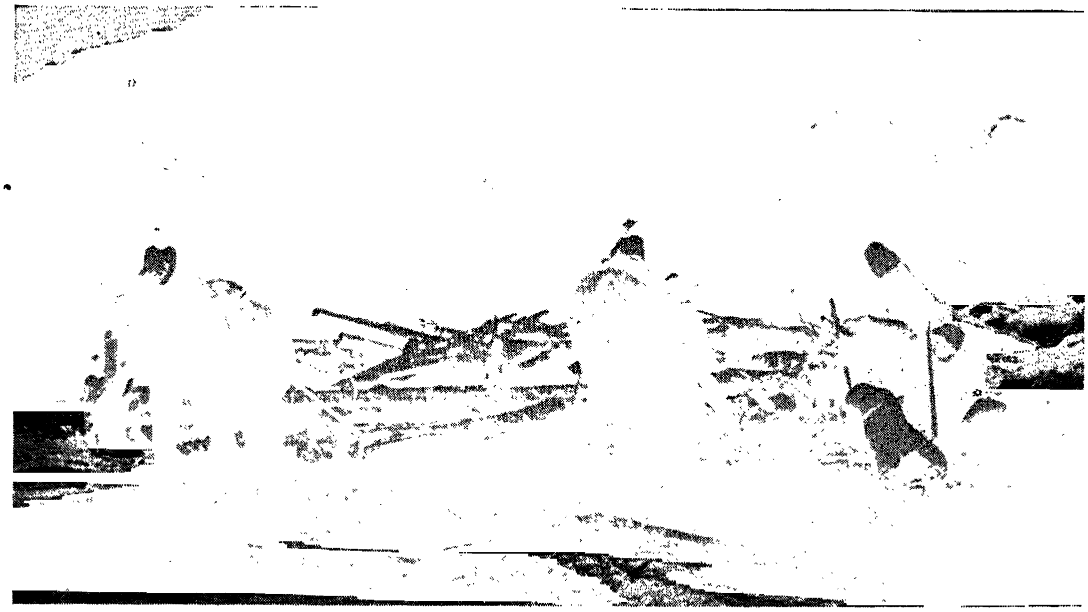
Least important of the general draft animals is the dog, rival to man in his ability to live in all climates. In Alaska alone some 25,000 huskies are used to pull sleds during the long arctic winter, but here and in the Canadian North Woods the dog sled is giving way to the airplane and tractor train, each train consisting of one tractor and three or four sleds carrying about 40 tons of freight. Dog sleds are also used in the colder parts of Europe and Asia, but it is probable that the dog is most used in the densely populated regions of northwestern Europe to pull small carts.

Draft animals of limited distribution. The five draft animals of special location are generally inferior to the horse and the mule. But they have some peculiar adaptation to environment that enables them to work in places where the horse and mule are less efficient or might not survive. Thus, the reindeer, caribou, and other species of the reindeer family are specialists in surviving the cold climate and meager feed supply of subpolar regions. In the short bright summers the arctic plains, or tundras, are green with shrubs, grasses, mosses, lichens, and flowers. In the long cold winters, however, the reindeer must search diligently for a morsel of vegetation beneath the snow. Reindeer are essential to the life of people in the northland from Lapland to Kamchatka and probably will be also from Alaska to Labrador. They are not only useful beasts of burden, but they furnish milk, meat, and skins.

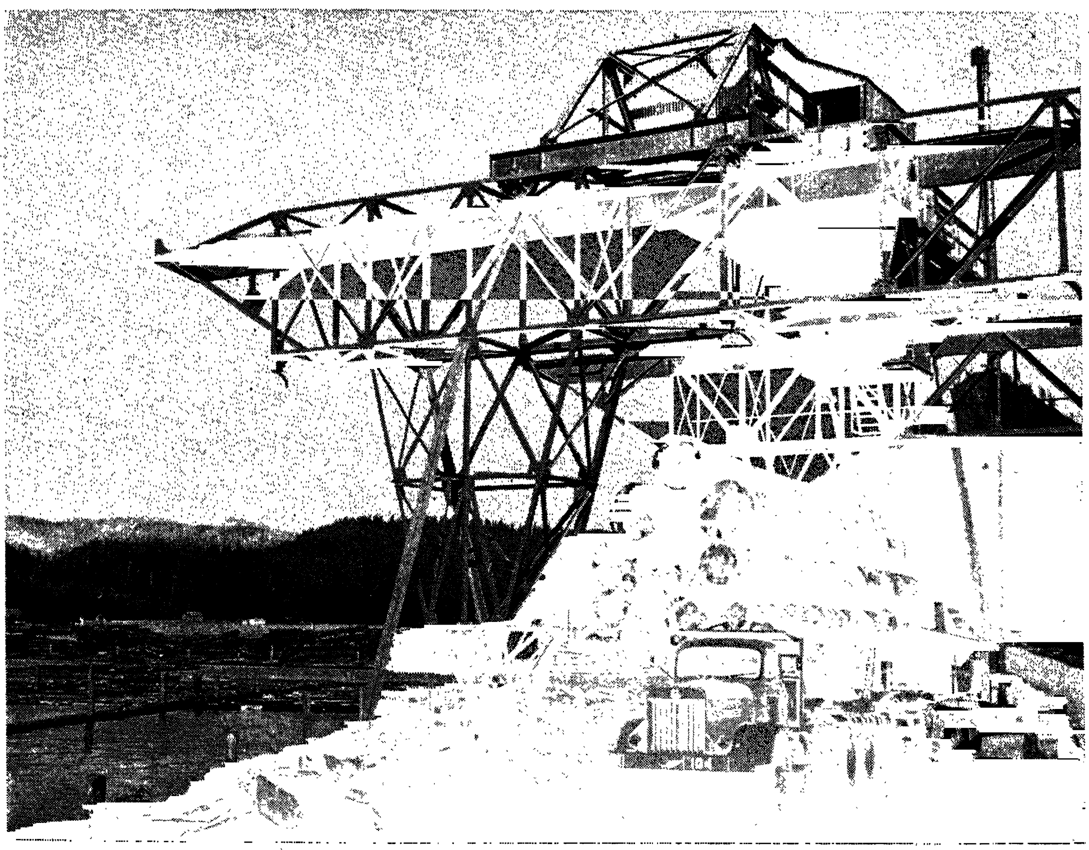
The yak, a close cousin of the ox and buffalo, is a native of the Himalaya Mountain region. He is well adapted to high elevations, scanty forage, and deep snow. The under parts of his body have long thick hair reaching nearly to the ground, a natural mattress providing warmth and comfort on a bed of snow and ice. The sure-footed yak is an ideal pack animal on the treacherous trails through the mountains of central Asia, and he pulls heavily laden carts on the wretched roads across the bleak plateau of Tibet.

The little llama of the Andes of Peru and

[8] See J. Russell Smith, *op. cit.*



Our greatest and most intelligent beast of burden is a wonder as he works the Asiatic pile of logs. But look at the 75-ton crane lift logs. They slide smoothly and sink quietly into the storage pond. Note the man by the truck. Four wheels at each corner. Some of these vehicles are not allowed on public roads—too big. *U. S. Forest Service*



Bolivia, like the yak of Tibet, is a cold plateau specialist. The llama does not have great amounts of snow to contend with, but this gentle, sure-footed animal has no superior in climbing the precipitous mountain trails. The llama resembles both the sheep and the camel. He is highly prized for his fine silky wool; he can travel long distances without water; and he picks a living from a very unpromising wayside. Because of his small size, the llama cannot carry loads exceeding 100 pounds.

For good reason, the camel has long been known as "the ship of the desert." His large stomach is lined with hundreds of cells or compartments capable of holding water, a veritable reservoir enabling the camel in extreme cases to go two weeks without water. He can live upon the harsh vegetation of the desert, and on his back are one or two humps of fat, an auxiliary energy supply. His nostrils can close almost like shutters and yet permit him to breathe in the midst of a desert sandstorm. His spongy feet are marvelous protection against sharp rocks and shifting sand. The Bactrian or two-humped camel, a native of central and eastern Asia, can carry loads of 700 to 1300 pounds. The fastest saddle camel can carry a man 100 miles a day. For ages the camel caravan has been a familiar sight in the vast Asiatic and African deserts. No other animal has carried so much so far. You can see him today in the streets of Peiping, Samarkand, and Casablanca and every city in between.

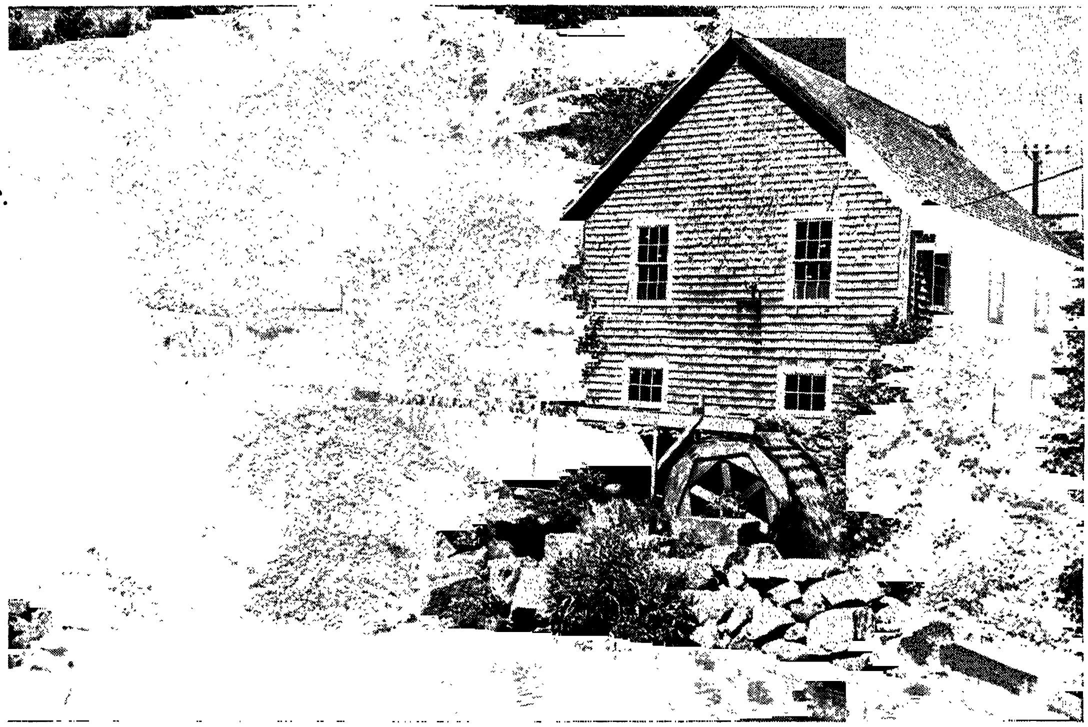
Elephants, the largest of land animals, are denizens of the tropical rain forests of Asia and Africa. The dense vegetation of such regions easily satisfies the elephant's well-known appetite. With the exception of a few animals that are trained for life in a circus, elephants have been domesticated and put to work in modern times only in the moist lands of southern Asia. Here they are used to carry passengers, to draw plows and big carts, and to lift heavy loads. Probably their most useful service today is in the teak forests of Burma, Thailand (Siam), and Indochina, where these living cranes lift and pile heavy logs with great dexterity and poise.

3. THE MECHANICAL REVOLUTION: DIVIDER OF MANKIND

The shift to inanimate energy. With few exceptions, the world's work for centuries was performed by man and beast just as it is in large areas today. The exceptions were the crude sailboat, a few windmills, and the typical small rural water wheel that operated George Washington's flour mill—colonial American and European type (Fig. 27 top). The supply of energy, therefore, was limited by the supply of food and feed. It was not until James Watt developed a practical steam engine in 1769 that man witnessed the dawn of the Machine Age.[9] In this modern era man's energy supply came to be multiplied many times through the use of power-driven machinery utilizing the tremendous power of coal and water power and, later, petroleum and natural gas.

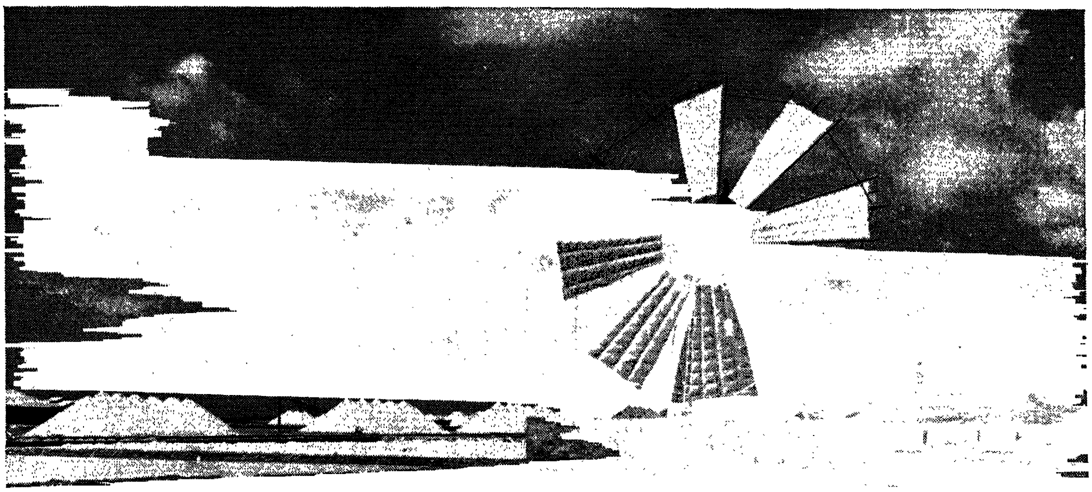
The invention, perfection, and general adoption of power-driven machinery came about gradually. The first textile mills of Lancashire and Yorkshire used water power, but the new engine was a great improvement over its predecessors as well as the water wheel. Between 1775 and 1800, 314 Watt steam engines were installed in England and Scotland,

[9] "Mechanical power is the result of the efforts of many minds, some dating back more than 2,000 years. Various mechanisms and machines [in rudimentary form] were invented by man centuries ago to aid him in his labors; these, however, were insufficient to free him from drudgery until 1769, when James Watt succeeded in bringing out a practical prime mover, embodying nearly all the principles that were afterwards perfected in the modern steam engine. Engines were used for about 65 years before Watt, for pumping water from mines; while they were called steam engines, they were actually atmospheric engines in that they used steam chiefly to produce a vacuum below the piston. The necessity of finding better means for pumping water out of mines and particularly out of coal mines was mainly responsible for Watt's contribution which started the wheels of the world in motion. By demonstrating how to turn heat into mechanical work effectively, Watt helped to create an improved civilization by stimulating through his own work all forms of inventions." National Resources Committee, *Technological Trends and National Policy*, Washington, June 1937, p. 262.



This old mill on Cape Cod, Mass., has worked for about 3 centuries, grinding grain or making cloth or charming summer visitors. It works by the *weight* of the water in pockets (buckets) on the wheel. The height of the wheel limits the height of fall that can be used. George Washington built and owned such a mill to make flour to ship in his own schooner. *Cape Cod Chamber of Commerce*

The wind—it has worked a bit in many lands, but not much. Its strong point is lifting water where any time will do. This one lifts the Indian Ocean into the salt pans at Aden. *British Overseas Airway Corp.*



114 of which were in textile mills. As one invention led to another, the power-driven machine eventually came to be increasingly used not only in manufacturing and mining but in transportation, agriculture, fishing, forestry, and other economic activities.

From its English home the use of power-driven machinery gradually spread to the United States, continental Europe, and eventually to many distant portions of the world, although there still remain vast areas in the world today that have been scarcely touched by the impact of the Machine Age. With the advancement of science, the Mechanical Revolution gained great momentum, and it has reached such proportions in this country that it seems that almost any kind of work can be done today by merely throwing a switch, turning a valve, pulling a lever, pushing a button, or holding a steering wheel.

This was a true revolution. Nothing so completely changed the life of civilized man as did the coming of the Machine Age. Throughout the centuries prior to the Mechanical Revolution, man's great occupation was agriculture. Land was his prime resource and was usually measured in two dimensions as so many units of farm or grazing land. Manufacturing remained in the handicraft stage and was decentralized in workshop and home to be near the food supply. Farming and manufacture developed in the same localities. Commerce was confined largely to a trade in luxuries, exotics, and other commodities of high value in proportion to bulk. Those few nations that rose to pre-eminent prosperity and political power were those favored by location and climate.

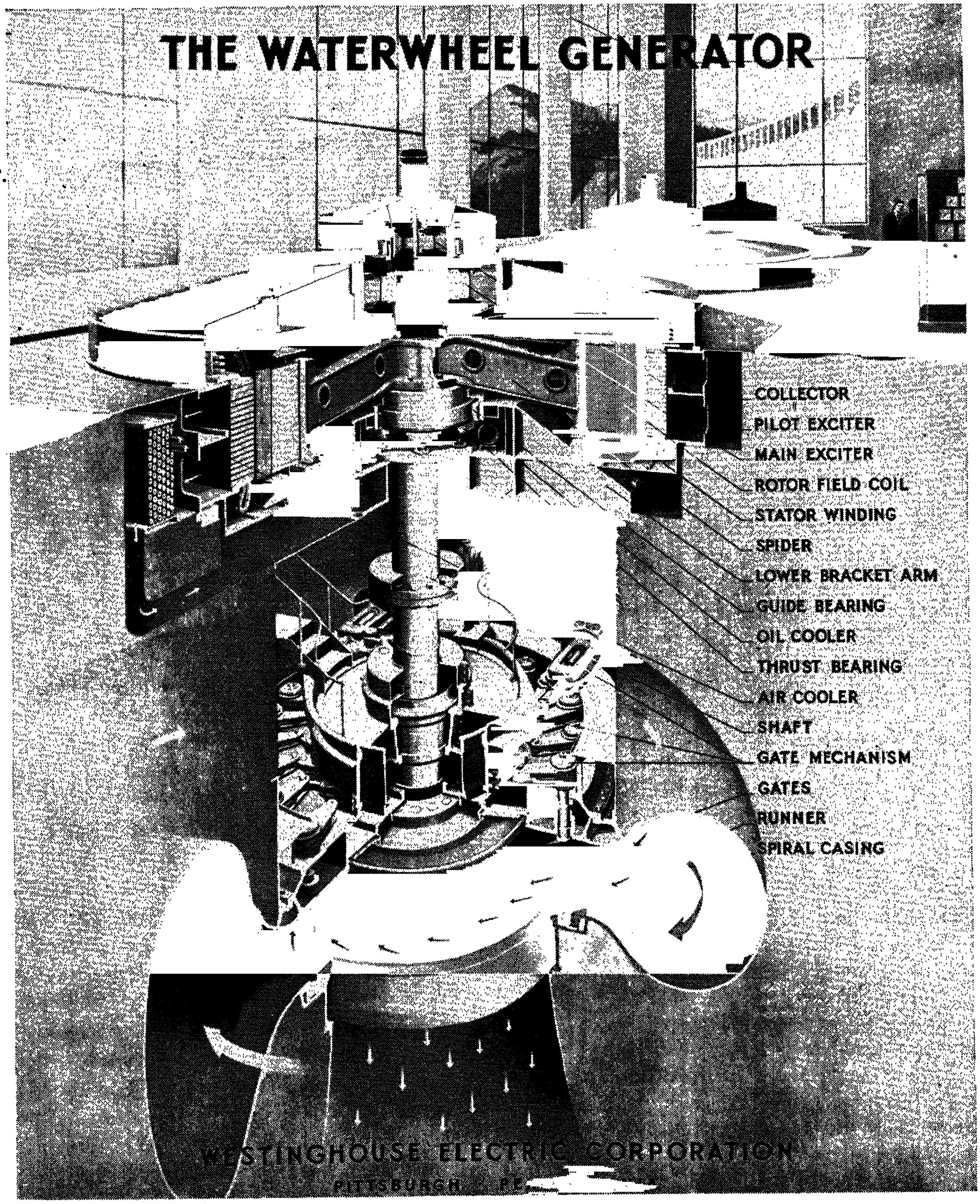
Then the revolution in power came to those lucky peoples having easy access to coal and iron and with sufficient ability and ambition to use them, chiefly the people of northwestern Europe and northeastern United States. Here the energy of man and beast came to be eclipsed by the billions of horsepower obtained from falling water and fossil fuels. Here manufacturing was developed in factories equipped with power-driven machines, and it became man's dominant occupation, with agriculture playing a subsidiary and often dwindling role. As the new industrialized urban areas continued to grow, so did their exports of manufactures and their imports of low-valued, bulky foodstuffs and raw materials, a movement produced by steam transportation, notably the steamship and the railroad.

Land now acquired an important third dimension, depth, to include mineral wealth below the ground. Economic and political power came to be concentrated in the hands of a few industrial nations, those that held easy access to coal and iron, the two main bases of the Machine Age.

Inequalities resulting from the Mechanical Revolution. One of the most significant results of the Mechanical Revolution is the inequality that is created. The power-driven machine increased greatly the productivity of human labor, but this advantage did not come equally or in the same manner to all industries, regions, nations, and peoples.

Some industries lend themselves to mechanization more readily than others. Whether or not power-driven machinery will be used depends largely upon the technical difficulties to be overcome in devising a machine for a given task, the cost involved, and the ultimate profit to be derived. The more a task can be subdivided, the more easily can machinery be used. For example, no single machine has been devised to turn out a complete and finished shoe from leather, but machines have been invented that readily perform each of the dozens of successive steps in shoemaking. In modern automobile production the raw materials are made into approximately 15,000 standardized parts, which are combined into nine primary units and assembled into a complete car. Thousands of jobs are involved, and nearly all are mechanized. Hence, division of labor, involving task specialization, increases the possibility of mechanization. Thus, those industries that can use the power-driven machine continuously and on a large scale tend to grow. The automobile is perhaps the most perfect example of mechanization and division of labor.

While exceptions are to be recognized, in



Turbine water wheel. It acts by *pressure* of water, in a long pipe, from a reservoir far above. Water surrounds the wheel, as shown by the nearly horizontal arrows and spurts in through slits and strikes the fins of the wheel from all sides and then falls vertically away (vertical arrows). Turbine on one end of shaft; dynamo on the other. Note the row of dynamos. *Westinghouse Electric Corp.*

general it may be said that manufacturing, transportation, and mining have been able to make far more extensive and effective use of power-driven machinery than have farming, grazing, forestry, and fishing. This inequality is to be found in the United States, which is universally regarded as the very quintessence of the Machine Age. While Americans have come to lead the world in the use of inanimate energy in virtually every branch of economic activity, the fact remains that the benefits of the power-driven machine have not accrued equally to all industries, as the following account of the difficulties of the American farmer indicates:

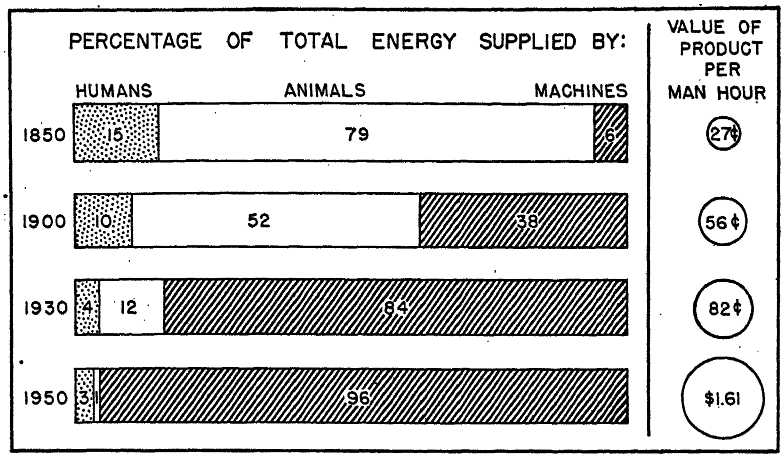
The farmer is indeed a victim of circumstances. Consider the contrast between him and the big manufacturer. Eastman may hold a patent on kodaks and Dupont a patent on how to make rayon, but no farmer or group of farmers can get a monopoly on sunshine, rainfall, soil, or how to grow spinach. The factory engineer can turn on or shut off his steam and electricity, but nobody can control solar radiation. Swift and Armour can speed up or cut down their production schedules, but a calf belonging to Farmer Jones takes as long to mature into a cow as it did in the days of Methuselah. The production of Packards can be spread evenly throughout twelve months of the year, but farm crops arrive on the market in concentrated doses, with a concomitant drop in prices. The output of Chesterfields or Lucky Strikes can be set at any figure, but pity the Secretary of Agriculture who tries to control the cotton crop without knowing what the yield will be. Goodyear can determine the quality of its tires with micrometric precision, but nature, more often than man, sets the quality of farm produce. The sulfur-producers of America and Sicily can divide the world into exclusive sales territories, but just try to get a lasting agreement among the wheat-producers of the world, of a nation, or even of one county! Westinghouse can operate its machinery twenty-four hours a day if necessary, but the wheat machinery of Farmer Jones is just so much idle capital during three hundred and fifty days of the year. The more automobiles Chrysler can run off the assembly line, the lower is the cost per car—but the more bushels of potatoes a farmer can extract from an acre of soil with increased labor, fertilizer, etc., the greater is the cost per bushel. General Electric can run its laboratories day and night to invent what it wants, but the farmer can only take or leave the farm implements that are offered for sale. Henry Ford can declare independence from the bankers and finance himself out of an accumulated surplus or by sales quotas imposed on his dealers, but Farmer Jones must go hat in hand to the storekeeper, the landlord, or the banker and pay whatever may be asked for credit. The number of manufacturers that are outside the realm of competition is remarkable, but the farmers, operating under competition, must take whatever price they can get.[10]

Do not let this rehearsal of the difficulties of the farmer in the Machine Age cause you to think that agriculture has not been mechanized. It has. It too has been revolutionized, but it is a pigmy of a revolution when compared to the factory revolution.

Since the Mechanical Revolution did not raise all industries to a common level of productivity, it brought unequal benefit to the peoples of the various regions and nations of the world. It is not to be denied or minimized that the development of the steamship, the railroad, the automobile, refrigeration, the dynamo, farm machinery, the windmill, and a thousand other wonders of the Machine Age have brought tremendous benefit to the peoples living in many agricultural and pastoral regions. And not to be discounted are the consequences from the use of donkey engines, caterpillar tractors, mechanical saws, and other machinery in modernized lumbering or the use of steam and Diesel trawlers in some of the world's great fishing grounds. Yet the fact remains that, since the coming of steam, no nation living under a purely vegetable–animal economy has risen to the rank of a Great Power, either politically or economically. Nor can it. A Great Power is great because it can use machines in the whole gamut.

Machinery and world power. Political

[10] J. Russell Smith and M. Ogden Phillips, *North America*, Harcourt, Brace & Co., New York, 1942, p. 425.



A century of power development in the United States.

This graph shows the power revolution at a glance and also tells why wages have been able to rise. *Twentieth Century Fund*

power depends upon military might. Victory in modern warfare goes to the nation with the largest manpower equipped with the most and best machines. Hence, only those nations can achieve great political power that have well-developed heavy-manufacturing industry capable of producing the materials needed to make hydrogen bombs, airplanes and carriers, artillery, and other implements of war, plus supplies, supplies, supplies. The Great Powers are the few nations that possess or have ready access to abundant energy and machine resources, especially coal and iron.

Great wealth and economic power have likewise come to be concentrated in the hands of a few great nations, especially within those urban-industrial-commercial regions that are the very core of our modern, capitalistic, mechanized, power-metal economy, notably northwestern Europe and northeastern United States. Here wealth accumulated over the years much faster and to a far greater degree than elsewhere. This unequal distribution of wealth and economic power is owing to the simple fact that the basic energy and machine resources of a power-metal economy are comparatively scarce and highly concentrated, whereas the basic resources of a vegetable–animal economy are comparatively abundant and widely and thinly scattered over the face of the earth.

While exceptions and differences of degree are to be recognized, in a world view it may be said that the products of factory and mine are relatively scarce, and their producers are few, concentrated, well organized, and frequently able to control output and price. On the other hand, the products of field, pasture, forest, and sea are comparatively abundant, and their producers are numerous, decentralized, highly competitive, and seldom able to control output or price. From any exchange of scarcities for abundances, the sellers of scarcities gain most. Hence, the people living in a power–metal economy gain far more from interregional trade than the people in a vegetable–animal economy, which cogently illustrates the old axiom of commerce that the benefits of trade are mutual but seldom equal. Furthermore, widespread foreign investments from the growing profits of commerce and manufacturing cause more and more economic power to accumulate in the great metropolitan centers of the power–metal economy.

Since nature did not distribute the vital deposits of coal and iron with an impartial hand, economic and political power came to be centered in the great urban-industrial-commercial regions of northwestern Europe and northeastern United States. Here the world's great citadels of heavy manufacturing, commerce, and finance developed. And in the 1930's the Soviet Union joined the ranks of the industrial giants. Economically and politically, this is "the world that matters," although the rest of the world has more people, far more. Furthermore, it should be noted that the hegemony of coal and iron has not been seriously affected

by the decentralizing influence of the electric-power wire carrying energy derived from coal, petroleum, and water power or by the increasing use of copper, aluminum, and other machine resources. Electricity merely subdivides power and spreads it within the power area.

Through the inequality that it created, the Mechanical Revolution has come to be the great divider of industries, regions, nations, and men. Today, as never before, the world stands divided into active and passive, dynamic and static, developed and "underdeveloped," strong and weak, sovereign and subject, lender and borrower, rich and poor. Keystone of world economic and political power is the inanimate energy that drives the machine, the energy that so greatly increases the productivity of human labor whether at peace or at war.

4. ANIMATE *VERSUS* INANIMATE ENERGY IN THE WORLD OF TODAY

Manpower and animal power in southern and eastern Asia. The Mechanical Revolution brought great benefit to some regions, less to others, and little or almost none to remarkably large areas of the earth. For us, the gadgeteers who live amidst the wonders of the Machine Age, it is rather difficult to realize that hundreds of millions of men have had little, indeed almost no, contact with the power-driven machine and that in vast areas the daily output of work continues to depend, as it has for centuries, upon human labor that is sometimes aided by the energy of draft animals and an occasional truck, bus, or auto.[11] Yet such is the case in parts of rural America, in the vast polar and subpolar regions, in hundreds of thousands of square miles of tropical "back country," and in the rural, semimedieval portions of Europe. It is especially true of southern and eastern Asia, the only large and densely populated sections of the world which the Mechanical Revolution has scarcely touched. (See Tables 2:1, 2:2, and 2:3.)

Throughout the Orient teeming millions continue to live in an ancient, unmechanized vegetable–animal economy, which has developed a commercial fringe along the seacoast, navigable rivers, and wherever a railroad penetrates the interior, and which also has acquired a modern industrial veneer in a few favored spots. Contrasts between these lands of man and beast and those of man and machine are striking.[12]

TABLE 2:1. Estimated Consumption of Commercial Sources of Energy in Terms of Coal for Selected Countries in 1952

Country	Millions of metric tons	Metric tons per capita
United States	1,230.3	7.84
Canada	99.9	6.92
Norway	16.0	4.81
United Kingdom	236.5	4.66
Sweden	27.1	3.81
Belgium-Luxembourg	34.1	3.78
Australia	30.3	3.51
Germany, West	152.4	3.14
France	98.6	2.32
Japan	75.8	0.89
Greece	2.1	0.27
India	39.9	0.11

Note: Data for U. S. S. R. are not available.
Source: Adapted from United Nations, *Statistical Yearbook, 1953*, New York, 1953, Table 127, pp. 277–278.

The coming of plantation agriculture to parts of southeastern Asia and the development of modern manufacturing in the Tokyo–Osaka and northern Kyushu areas of Japan, in Shanghai, Calcutta, Bombay, Jamshedpur, and other favored spots have not materially changed conditions under which the masses of southern and eastern Asia live. Here the good earth and the rain-bearing monsoon wind are man's prime resources, for 3 men out of 4 are engaged in tilling the soil with the same, or almost the same, primitive methods that their ancestors have used before them for many centuries.

Nowhere in the world does one find such a heavy concentration of humanity upon arable

[11] See Heinrich Harrer, *Seven Years in Tibet*, E. P. Dutton & Co., Inc., New York, 1953.

[12] For interesting observations on the resource patterns of large areas of the world, see Erich W. Zimmermann, *World Resources and Industries*, rev. ed., Harper & Brothers, New York, 1951, pp. 127–143.

land as in rural Japan, China, and India where 1000 to 4000 people per cultivated square mile are not uncommon. In many areas the land cannot support both man and draft animals. In large parts of China one sees no animals larger than a chicken or a pig—both are scavengers—while in most of Japan there are no pigs, and a chicken is indeed a luxury. Good rice land is worth as much as $500 to $1200 an acre, and wages are less than $1 a day. In a land of high rents and midget landholdings, averaging 2½ to 3½ acres per family, superintensive cultivation of the land is absolutely necessary, and a huge amount of human energy is applied to each plot of ground. Where climate permits, the land is used to grow two or three crops a year.

Especially in China the rural masses are almost as immobile as the soil upon which they work. Travel on foot or by jinrikisha, sedan chair, or two-wheeled cart is slow and fatiguing. Beyond the railroad or waterway, freight moves in carts, wheelbarrows, two packages balanced on the carrying pole, or on the backs of human porters, the strongest of which can carry 100 pounds about 15 or 20 miles a day. Wherever there is immobility of persons and goods, there is also an immobility of ideas, a factor that helps to perpetuate a static civilization. Most manufacturing remains in the handicraft stage, decentralized in workshop and home. Where mining occurs, primitive methods predominate. All forms of work draw heavily upon human labor, and hours of toil are long. Under such conditions the pressure of population upon all available resources is terrific, and a bare subsistence standard of consumption prevails, and infanticide is far from unknown. (It is probably more correct to say that it is common. Read Pearl Buck's book *The Good Earth.*)

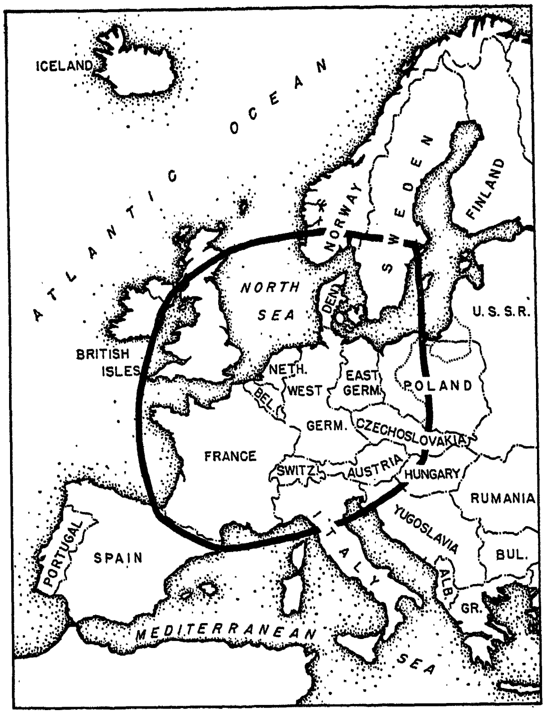
A survey of the problems of southeastern Asia reveals the striking contrast between Oriental and North Atlantic civilization.[13] Throughout India, Pakistan, Burma, Thailand, Ceylon, Indochina, Malaya, Indonesia, and the Philippines man uses only ½ horsepower-hour of mechanical energy per day as compared with 26.6 horsepower-hours in the United States and western Europe. The average southeastern Asiatic has an annual income of $35, as compared with $461 for North Atlantic man. Although 1800 calories of food a day are usually needed to sustain life, the southeastern Asiatic gets along on 1750 calories a day, as compared with a food intake of 2950 calories in the United States and western Europe. In southeastern Asia there is only 1 physician per 10,000 persons, as compared with 17 physicians in the North Atlantic countries. The southeastern Asiatic dies when he is 32½ years old, while North Atlantic man has a life expectancy of 64 years. If this survey had included China, the contrast might be even worse!

Highly mechanized northwestern Europe. Whereas the teeming millions of southern and eastern Asia continue to rely dominantly upon human labor, striking contrasts are to be found within the Europe of today, where inanimate energy plays a decisive and dividing role. The little continent, excluding Soviet Russia, may be divided into two different parts.[14] Within a rough circle that may be drawn through Bergen, Stockholm, Danzig, Cracow, Budapest, Florence, Barcelona, Bilbao, and Glasgow (see Fig. 34) is to be found the highly dynamic civilization of modern scientific, mechanized Europe. Here is a highly developed power–metal economy based upon the intensive use of coal, iron, and water power.

This portion of the European continent is a land of big cities, modern factories, energetic men, and millions of mechanical horsepower. Manufacturing is the dominant occupation, and to the big urban areas are brought each year vast quantities of foodstuffs and raw materials. This area ships many manufactured goods to overseas markets. In normal times

[13] "The Vast Economic Problems Confronting Southeast Asia," *The New York Times,* Section 4, October 15, 1950, p. 3.

[14] See Francis Delaisi, *Les Deux Europes: Europe Industrielle et Europe Agricole,* Payot, Paris, 1929.



West Europe and its major manufacturing zone. Note the boundary of prewar Germany.

the internal trade of this part of Europe is large despite a multitude of crippling boundaries and tariffs. Here people, goods, and ideas are mobile, for this land of short distances is well covered by a dense web of railways, highways, airways, and well-used rivers, together with modern means of communication. Here the productivity of man has been greatly increased through the use of the power-driven machine. The population is dense, but the pressure of people upon available resources is not nearly so great as in the Orient. The standard of consumption of goods and services throughout western Europe is much higher than in the Orient but lower than in the United States.

World War II dealt many cruel blows to the nations of Europe. Perhaps the worst was the fate of East Germany, Czechoslovakia, Poland, and other countries that became victims of Russian domination. In these countries individual initiative has been suppressed, the productivity of labor has fallen, and the standard of consumption has sharply declined. An "Iron Curtain" now separates the Russian satellites from the free nations of the West, and travel and trade between them has nearly ceased. In free western Europe the standard of consumption generally remains below its prewar level as a consequence of disrupted trade, the costly sacrifices made in restoring devastated areas, rebuilding industries, and rearming for defense. If the western European nations can continue to cooperate for the common good, their inanimate energy resources will be a great asset in postwar economic recovery.

Little-mechanized peripheral Europe. Beyond the periphery of modern, mechanized, northwestern Europe lies a different land—the old, semimedieval, unindustrialized, and little mechanized Europe. Throughout most of peripheral Europe one finds a little-mechanized vegetable–animal economy, with agriculture—symbolized by the ox team—playing the dominant role. Railroads and highways are few and far between, and man suffers from immobility. In this part of Europe, old customs, costumes, dialects, and primitive methods of farming have survived for centuries, especially in the more isolated areas. With little education, many men work under conditions not far removed from serfdom. Without coal and iron, manufacturing is unimportant. Mineral products, such as petroleum and sulfur, are largely exported to outside markets. The population is not so dense as in northwestern Europe, but the pressure of people upon available resources is much greater (see Fig. 234).

The mechanical revolution in the Soviet Union. Under the czarist regime and indeed as late as 1930, the vast Russian domain resembled semimedieval peripheral Europe. In 1929 approximately one third of the nation's work was performed by human labor, and at least 23 countries surpassed the Soviet Union in output of work per capita (see Table 2:2). Today the U. S. S. R. holds a position of political and economic power second only to the U. S. A. The rapid rise of the Soviet Union was stimulated by new social objectives; it was based upon a great wealth of natural resources;

TABLE 2:2 The World's Output of Work, 1929 and 1939

	Human		Millions of horsepower hours: Coal		Petroleum		Water		Total		Population, millions		Daily output per capita, hp-hr.	
	1929	1939	1929	1939	1929	1939	1929	1939	1929	1939	1929	1939	1929	1939
United States	40	43.8	1,001[a]	784.4[a]	481	617	121	166.7	1,643	1,611.9	122.77	131.41	13.38	12.27
Canada	3.3	3.7	55	39.6	17.6	25.4	59	104.8	134.9	173.5	10.35	11.02	13.03	15.74
Norway	0.9	1.0	3.6	4.6	0.6	2.57	15	26.5	20.1	34.7	2.65	2.94	7.58	11.80
Belgium	3	2.8	50	43.1	1.7	3.5	....	0.03	54.7	49.4	7.99	8.39	6.85	5.89
Great Britain	15	15.4	270	302.7	28.3	45.5	4	4.4	317.3	368.0	47.71	46.21	6.65	7.96
Germany	21	37.7[b]	333	548.9[b]	9.5	27[b]	13	33.1[b]	376.5	646.7	62.34	113.15[b]	6.04	5.72
Sweden	2	2.1	7.5	14.4	1.9	5.3	16	20.4	27.4	42.2	6.12	6.31	4.48	6.69
Switzerland	1.3	1.4	3.9	5.4	1.0	1.3	11.5	24.4	17.7	32.5	4.02	4.21	4.41	7.72
France	14	14.2	127	101.0	12.3	25	24	43.2	177.3	183.4	40.74	42.42	4.35	4.32
Czechoslovakia	5	[c]	42	[c]	1.8	[c]	1.5	[c]	50.3	[c]	14.52	15.25	3.46	[d]
Australia	2.1	2.2	10	26.0	10	7.4	[e]	2	22.1	37.6	6.43	6.96	3.44	5.40
Austria	2.2	[c]	12	[c]	0.9	...	6	[c]	21.1	[c]	6.67	7.01	3.16	[d]
Union of So. Africa	2.3	3.4	16	25.5	1.8	3.7	[e]	.09	20.1	32.7	6.93	10.16	2.90	3.22
Holland	2.5	2.9	16	21.6	3.1	5.9	...	...	21.6	30.4	7.62	8.73	2.83	3.48
Poland	10	[f]	48[a]	[c]	1.7	[d]	[e]	[c]	59.7	[f]	30.84	34.77	1.94	[d]
Chile	1.5	1.5	2.0	2.7	3.8	2.7	1.0	1.8	8.3	8.7	4.36	4.63	1.90	1.88
Japan	21	24.3	52	[d]	7	12.7	30	49.1	110	[d]	62.94	72.80	1.75	[d]
Argentina	3.6	4.3	4.5	[d]	10	14.4	0.35	0.54	18.45	....	10.90	13.01	1.69	[d]
Italy	14	14.7	23	20.1	4.6	10.9	27	50	68.6	95.7	41.17	44.03	1.67	2.17
Spain	7.6	8.5	13	10.5	1.8	2.85	8	11.2	30.4	33.05	22.75	25.37	1.34	1.30
Mexico	5.5	6.5	1.5	9.5	9.5	9.3	4.0	3.8	20.5	29.1	16.40	19.48	1.25	1.49
Hungary	2.8	3.7	6	17.1	0.8	1.0	[e]	.04	9.6	21.8	8.60	11.14	1.12	1.96
Rumania	6	6.7	4.1	3.9	6.8	7.5	0.8	1.0	17.7	19.1	17.39	20.09	1.02	0.95
U.S.S.R.	53	56.9	56	219.7	35	85.3	4	15.3	148	377.2	158.50	170.47	0.93	2.21
Bulgaria	2.0	2.2	2.4	0.6	0.3	...	0.5	0.6	5.2	3.4	5.60	6.55	0.93	0.52
Yugoslavia	4.4	5.2	4.2	9.7	0.5	...	2	2	11.1	16.9	13.29	15.63	0.84	1.08
Peru	1.8	2.3	0.4	0.2	0.9	1.3	0.5	1.4	3.6	5.2	5.50	6.92	0.66	0.75
Brazil	13	14.7	3.4	2.2	3.0	4.4	6	8.9	25.4	30.2	40.27	44.12	0.63	0.68
India	106	117.8	34	40.3	8	8.2	3	5.0	151	171.3	318.88	352.84	0.47	0.49
China	133	161.1	43	55.1	4.13	3.4	[e]	...	180.13	219.6	400.80	482.30	0.45	0.46

[a] Includes natural gas.
[b] Includes Austria, Czechoslovakia, and two thirds of Poland.
[c] Included in Germany.
[d] Data lacking.
[e] Quantities omitted; too small to be important.
[f] Divided between Germany and Russia.

Source: T. T. Read, "World's Output of Work," *The American Economic Review*, March 1945, p. 144.

Kitimat power house: 712 x 81 feet and 134 feet high—cut out of solid rock ¼ mile back in the British Columbia mountain. The rotor (moving part) of a 150,000 h.p. turbine (largest in the world) being lowered into position. This room was planned for 1,120,000 h.p. See Figure 12.
Aluminum Company of Canada

Many thousands of ponds have been built on U. S. farms in a few years since the bulldozer proved its power. This boy with his 40 h.p. Diesel can go into a meadow and dig more pond and build more bank, much more, than can be done by 20 men and 40 horses. *Allis-Chalmers Manufacturing Co.*

it was made possible by scientific methods and power-driven machines; and it was executed by a determined dictatorial leadership with utter disregard for financial and human costs or personal liberty and even human life.

No longer can the Russian nation be regarded as an eastern appendage of peripheral Europe. Modern methods and machines have been introduced into every major industry. Henry Ford became the Paul Bunyan of Russia. Important manufacturing areas are developing rapidly. In total consumption of all types of energy for productive purposes, the Soviet Union is surpassed only by the United States and by the free nations of western Europe, if the latter may be considered as an entity (see Table 2:3). The Soviet Union now ranks second only to the United States in the production of electric power.[15] In coal and steel output, it is surpassed only by the United States.

TABLE 2:3. Estimated Energy Consumption for Productive Purposes, 1948

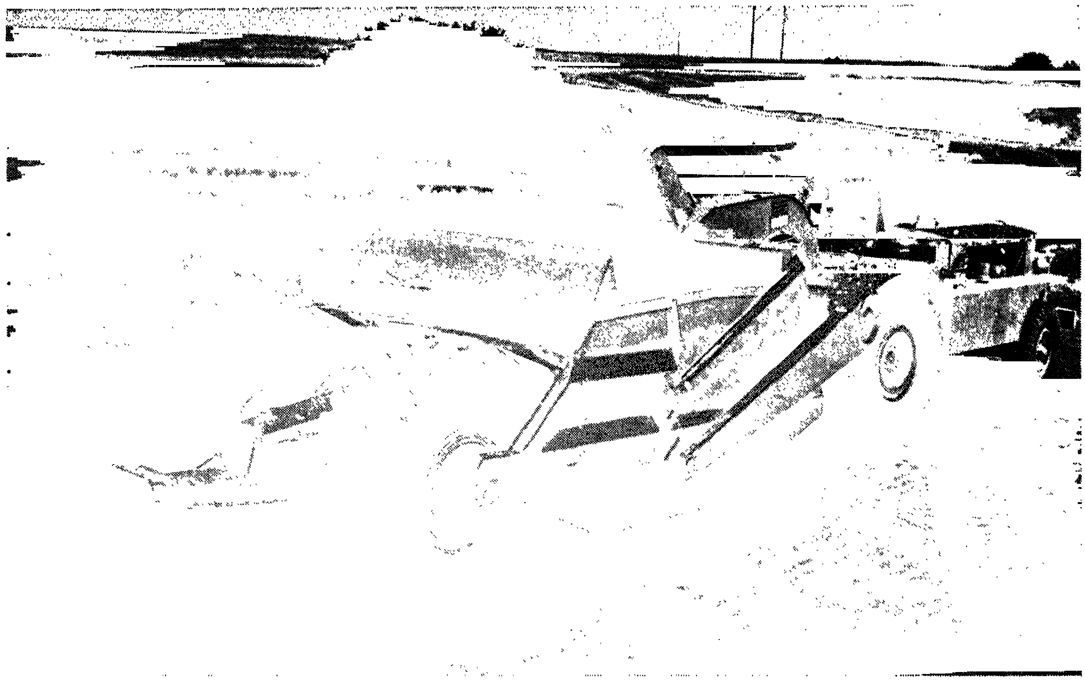
Country	Total, billions of kw.-hrs.	Per-capita, thousands of kw.-hrs.
United States	1,562.7	10.3
U. S. S. R.	460.4	2.4
United Kingdom	294.9	5.9
Germany	164.5	2.5
France	132.2	3.2
India	120.3	.3
Canada	112.3	8.0
China	74.0	.2
Japan	73.8	.9
Poland	67.5	2.7
Belgium-Luxembourg	49.7	5.5
Italy	48.8	1.1

Note: Data include animate and inaminate sources of energy in units equivalent to billions of kilowatt-hours. Data for European countries are adjusted for 1937 boundaries. Chinese data include Formosa and Manchuria. Per-capita data are based upon postwar population.

Source: Total consumption data from U. S. Department of State, *Energy Resources of the World,* Washington, 1949, Appendix G, Figure 14.

When economic progress is measured on a per-capita basis, however, the Soviet Union does not rank so high. It is estimated that the

[15] See Eric Thiel, "The Power Industry in the Soviet Union," *Economic Geography,* April 1951, pp. 107–122.



Power. **As this new beast of burden moves along, the driver pulls a lever. The scraper drops to earth, scrapes it up, fills body of machine. A pull on another lever, scraper rises, clears the ground, and the load moves away to be dumped by another pull of lever. Very important for good roads.**

In 1954 Spanish road workers shoveled dirt into the baskets on the backs of donkeys. A cost comparison: moving a cubic yard by mule, by this, and by donkey. *Caterpillar Tractor Co.*

per-capita consumption of all energy fuels in the U. S. S. R. is only 18% of that in the U. S. A.[16] The output of goods and services per man-hour of work in the Soviet Union is less than one eighth of the United States output, about one fourth of the British output, two fifths of the French output, only double that of India, and four times that of China.[17]

While the Russians are developing a modern machine civilization similar to that of western Europe and the United States, there are significant differences. The Russians place a greater premium on guns than butter, and, in the hope of some future gain, they stress the production of producers' goods rather than consumers' goods. The Russian standard of consumption remains low. Railroads and highways are not well developed in the Soviet Union, and the average citizen lacks the mobility and many other freedoms of the typical American and western European.[18] The Russians make larger use of animate energy, and the use of forced labor is common. From the beginning of the Soviet regime in 1917, the nation's leaders have ignored one of the great lessons of history, namely, that the human mind and body are most productive under conditions of freedom. The new Russian civilization is clearly dynamic, but much progress remains to be made.

Power-driven machinery in rural America and other lands. In contrast to peripheral Europe and southern and eastern Asia are the rural areas of temperate-zone Australia,

[16] R. T. Haslam, Vice President, Standard Oil Company (New Jersey), "World Energy and World Peace," an address at the Massachusetts Institute of Technology, Cambridge, Mass., June 12, 1948, p. 11.

[17] These estimates by the Australian economist Colin Clark were at one time subject to criticism but were later confirmed by independent research of the U. S. Federal Reserve Board. "Back to 1900," *Time,* August 29, 1949, p. 18.

[18] See Table 26:1 and railway maps in Chapters 33–34.

New Zealand, Argentina, South Africa, Canada, and the United States. Here man lives in a modern, mechanized, vegetable–animal economy in lands that would be little more than a frontier wilderness had it not been for the coming of the steamship, the railroad, and the resulting trade. Modern transportation gives man in these vast areas cheap access to the world markets. Often he specializes in the production of a single, low-valued and bulky commodity, such as wheat, meat, wool, cotton, or lumber, but from the sale of this commodity he can buy the many things that he needs. His market and his source of supply may be thousands of miles away, but economically they lie within his reach. He can find the factory goods in the country store.

While the farmer and rancher cannot use power-driven machinery as liberally, continuously, and effectively as the manufacturer, nevertheless in large areas the common can of gasoline and the rapidly spreading electric-power wire are doing much to reduce the drudgery of life and to increase the productivity of human labor. Here the draft-animal population declines as tractors increase. Year after year the automobile, truck, tractor, water pump, electric light, telephone, radio, washing machine, refrigerator, and many other mechanical gadgets continue to invade the countryside in increasing numbers. Such a rural civilization is not static, for men, goods, and ideas continue to gain mobility.

Under such conditions one finds a relatively high standard of consumption, which would be higher and far more widespread if our modern system of distribution could distribute what our technology can produce. Financially, politically, and technologically, rural man has usually been subject to policies made by men in the great metropolitan centers, and his prosperity has risen and fallen with the price of his product as determined by the fickle forces of supply, demand, and connivance in some urban market far away. In the U. S. the battle is on to stop this, as we shall see in Chapter 4.

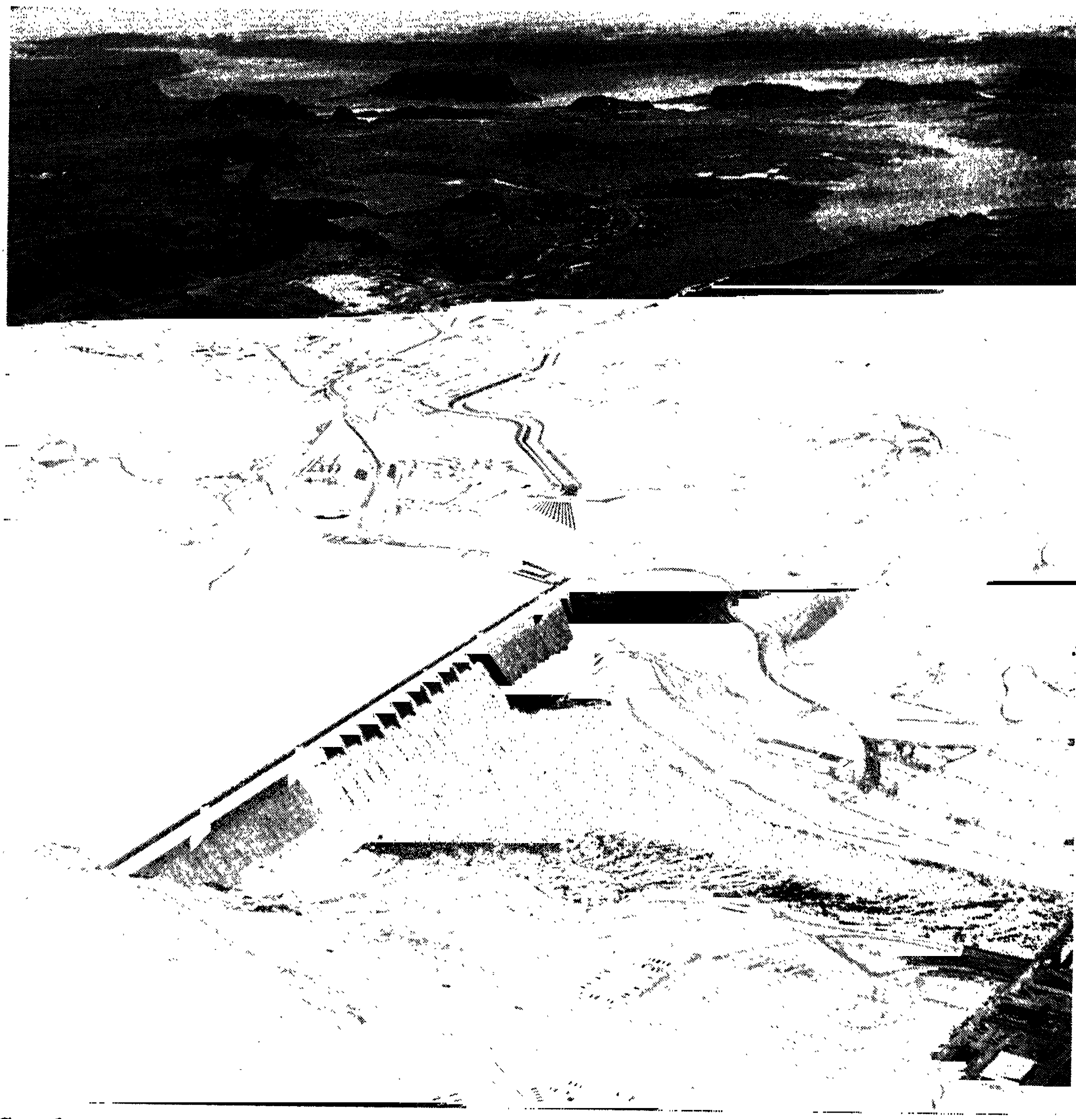
Northeastern United States: quintessence of the Machine Age. Only within the northeastern quarter of the United States has man created a wealthy, urban, industrial, and commercial area that has come to surpass northwestern Europe in many ways. Here is a land unfettered by tradition, undivided by national rivalries or political boundaries, relatively secure from invasion by land or sea, well located for world-wide commercial expansion, blessed with a stimulating climate, and richly endowed by nature with energy and machine resources. Here man has built with exceptional ease and rapidity a civilization that stands today as the supreme manifestation of the Machine Age.

Nowhere else does man make such lavish use of inanimate energy as in our lucky United States. In our manufacturing area man lives in a power–metal economy that contains many great centers of heavy manufacturing. In modern mills and factories large-scale production methods, power-driven machines, and cheap raw materials from a peerless hinterland combine to yield low costs per unit of output along with big profits, salaries, and wages. Within this region great wealth continues to accumulate rapidly. The standard of consumption is the envy of the rest of the world—although, in reality, prosperity does not always trickle down to the lower income groups, as the slums of the big cities so sadly illustrate. This region contains America's most densely developed web of railways, highways, airways, and waterways, and here the mobility of man reaches its highest peak. Of all the world's civilizations, past or present, this is the most dynamic.

The United States has had the incalculable advantage of being laid out and unified into one government before the Machine Age came along. Alas, poor Europe! Its many states! Its many tariffs! If there just could be a United States of Western Europe!

Some national power comparisons. The great bulk of the world's consumption of inanimate energy is concentrated in the very few countries that are the world's industrial leaders.

According to one postwar estimate, the



Grand Coulee Dam. Power plants at base have 9 turbines each. Each has 108,000 kilowatts; total capacity, 1,974,000 kilowatts. Dam is ¾ mile long. *A.* Pumping plant: lifts water 280 feet through pipes *B.* to canal. Canal, 2 miles long, leads to dam *D.* Dam makes reservoir for irrigation water. Dam, in river 150 miles long, has effective storage of 700,000 acre-feet. *C.* Electric transmission switches and control are too small to show in this wonderful photograph. *U. S. Reclamation Service*

United States, with 7% of the world's population, uses 45% of the world's energy fuel and has an annual consumption of 246 million heat units (B.T.U.) per capita.[19] Canada is the only nation that approaches us in per-capita use of energy fuel, the Canadian consumption being about 85% of ours. The European Recovery Plan nations of western Europe use about 25% as much fuel per capita as we do; the Soviet Union, 18%; other European and North African countries, 15%; Latin America, 6%; and Asia, Oceania, and the rest of Africa, only 3%. In consuming ten times as much energy fuel per capita as the rest of the world, the United States produces two to four times more goods per labor-hour than even the

[19] Haslam, *op. cit.*, pp. 11–12.

most highly industrialized foreign countries. Hence our high wages. We make the stuff.

Prior to World War II about 54% of the world's effective consumption of mechanical energy occurred in the United States.[20] In 1937–39 an average of 746 quadrillion foot-pounds of work was accomplished in this country each year by power-driven machines, using energy derived from coal, petroleum, natural gas, and water power. This was equivalent to the work of 20 billion inanimate slaves, or 153 slaves per capita.

No other country approaches the United States in the total amount of work performed by inanimate energy slaves, a fact that goes far to explain the high productivity of our labor and the final outcome of World War II. The output of man and machine is so much greater than that of man and beast that probably one half of all the work in the world today is performed in the United States (see Table 2:2). Certainly no empire in the days of human slavery ever accomplished in a year the work that is now done by the American people aided by billions of inanimate slaves.

Why this prodigious consumption of inanimate energy in the United States? In a country that has suffered from a shortage of labor throughout most of its history, man naturally has turned to the development and use of the power-driven, labor-saving machine. Unlike Europe, a large part of this country was settled and developed with the aid of steam. Indeed, largely because of our long distances, the United States has become the world's greatest experiment in transportation (see Tables 26:1, 33:1, 33:2, and railway maps in Chapters 33–34).

While the glories of our "wide open spaces" have been frequently extolled by poet, painter, and orator, in reality excessive space is a heavy burden upon American economic life. Each year we pay a terrific bill for transportation, since mobility is a daily and dire necessity. It cannot be assumed that each additional ton of coal burned under a locomotive boiler and that each additional gallon of gasoline consumed by an automobile yields a proportional increase in economic welfare or human happiness.[21] If this were true, we might well wish that the Appalachian and Rocky Mountains were twice as high and that the distance from New York to San Francisco were twice as great. The ubiquitous automobile is a sign of great prosperity, but it is a moving example of our daily attempt to overcome the handicap of excessive space. The giraffe is not necessarily better off because it has a long neck. Our tremendous transportation system is long, and without it American economic life would be paralyzed. Yet this system involves a big investment, great maintenance and operation costs, together with a vast expenditure of energy. A large part of the available mechanical power in the United States is tied up in transportation equipment and most of this equipment is idle much of the time (see Table 2:4).

TABLE 2:4. Where U. S. Horsepower Is

	Horsepower
Automotive	5,729,695,600
Power stations	117,852,000
Farms	115,672,600
Railroads	88,706,600
Construction equipment	78,421,250
Ships and boats	37,740,700
Factories	28,800,000
Aircraft	24,781,700
Mines	9,600,000
Miscellaneous	7,156,300
Total	6,238,426,750

Source: Steelways, August, 1954.

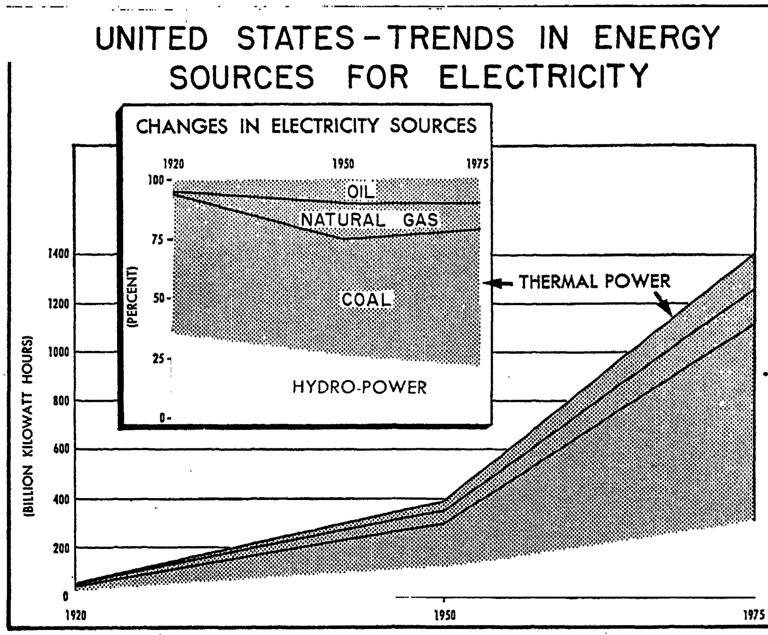
Nearly 92% of our horsepower is in automobiles, trucks, and buses. Compare this total with the live horses and mules—5,636,000—in the United States, January 1, 1953.

Advantages of inanimate energy. The inanimate energy slaves now in the service of man are far more useful and much cheaper than human labor or draft animals. No number of human slaves could substitute for the compact engine that drives a plane through the air at supersonic speed. No number of human

[20] R. Buckminster Fuller, "U. S. Industrialization," *Fortune,* February 1940, p. 163.

[21] See Zimmermann, *op. cit.,* pp. 74–79.

Percentages are valuable, but their value rises when you also know the quantity. Notice both in this graph. The rising rate of increase is well explained in the last chapter if you have not got it sooner. *President's Materials Policy Commission: Resources for Freedom, Vol. I, p. 119*



slaves could propel a modern ocean liner at a speed of 20 or 30 knots. No ancient Hermes could hope to deliver a message with the speed now attained through the use of the telegraph, telephone, and radio. No human slave could work 24 hours a day throughout the year like a power-driven machine.

The usefulness and low cost of inanimate energy in the United States is clearly revealed in the following description of the advantages of mineral energy:

In a single day, the Consolidated Edison System in New York delivers enough electricity to do the work of three million draft horses or ten times as many hard-working men. Last year the Consolidated System turned out about as much energy as the total work output of the entire nation in 1850!

The greatest advantage of mineral energy is that it is cheap as compared with animal or human energy. Cost is crucial. Many forms of energy have never been used because they cost too much to harness to practical uses. Wind power, for example, is both unlimited and free, but costly to use. Similarly, we have not learned a practical way of using atomic energy for peaceful purposes.[22]

Compared to machines, men and animals are costly. The upkeep is too high. Any farmer will tell you that horses spend more time standing around eating their heads off than working. Men have to be fed, clothed, and sheltered. That is why slave labor is not cheap. Our mechanical slaves get along on cheaper "food" and require less attention than either men or animals. Aside from the morals involved, the use of forced human labor is a sure sign of industrial backwardness.

Electricity is delivered at a cost of one to four cents per horsepower-hour. A draft horse can be hired for 75 cents an hour. The present rate of $1 an hour for common labor would mean that human energy would cost $10 per horsepower-hour.

On the whole, animal energy probably costs thirty to a hundred times as much as mineral energy, and human energy from three hundred to a thousand times as much. No wonder that we waste everything but man power! No wonder we electrify our kitchens as well as our factories. We even have "mental" labor-saving machines—for example, the electronic calculator that performs such astonishing feats as multiplying 94,267,546,829,347 by 74,392,864,576,249 in one-fiftieth of a second. No wonder Americans are accused of being demons for speed and efficiency. In purely practical terms, we want to get the

[22] An atomic submarine has been built, and atomic airplanes and locomotives have been planned.

most out of our costly man power, so we devise mechanical marvels to replace it, supplement it, augment it, and conserve it.[23]

The gains from the use of inanimate energy are not to be measured solely in dollars or goods. Neither are they to be measured only in horsepower or kilowatt-hours. Perhaps the greatest of all gains from the modern Machine Age is that man has more time for relaxation and thought. But how many of us use leisure for thought? As yet, no robot can hope, invent, or plan.[24] Mr. Woytinsky has said that the difference between civilized and uncivilized men is not in the tools they use but in what men do when they are not working.

In comparison with other organic creatures, man is deficient in many ways. The eagle can see 50 times farther than man, and the owl can see in the dark. The dog has a more powerful sense of smell. A bear can sleep four months without food, and a camel can go without water for two weeks. The fish, the bird, the squirrel, and the mountain goat, each in its own way is more proficient than man. A turtle lives five times longer, and the rabbit is far more prolific. The horrendous gorilla is many times stronger, and a draft horse can do ten times as much work. In one vital respect, however, man is unique. For good or evil, man's brain power makes him superior to all created things. We have been told that Thomas Edison had on his laboratory wall a brass plaque with these words: "Man will do almost anything to avoid the pain of thinking."

Problem of the Machine Age. Coal, petroleum, and natural gas perform fully 87% of all work in the United States. Water power accounts for about 7%, while the contribution of men and animals is less than 6%. In 1960 human beings will probably contribute a mere 2½% of the nation's energy output.[25] By far the lion's share of the world's inanimate-energy supply is consumed in the United States. One of the great postwar problems is to increase the production and consumption of inanimate energy in foreign lands.

Sizable coal and petroleum reserves are known to exist in many backward areas. With American "know-how" and financial aid, it is hoped to develop mineral deposits abroad and to introduce scientific methods into agriculture, manufacturing, and other industries. Such a program may appreciably increase the productivity and standard of consumption in foreign countries—provided that an increase in population does not beat down the standard of consumption to a subsistence level, as it has done in the Orient for centuries. Again, the controlled export of fissionable material in an Atomic Age might prove to be the greatest decentralizer of industry that the world has ever known.

Of long-run significance is the fact that the United States and other great industrial nations depend so heavily upon the fossil fuels for their supply of inanimate energy. Indeed, more than three fourths of the world's energy supply is now derived from fossil fuels.

What is the fate of our proud mechanized civilization when the coal, petroleum, and natural gas are gone? Will some future Marconi perfect the long-distance transmission of power by radio thereby permitting man to use the huge water-power reserves of interior Africa and of South America? They would be insufficient before we got them harnessed. Will some future Watt perfect a solar engine which will enable man to harness to his modern and complex machinery the inexhaustible energy of the sun?

To some industries, regions, nations, and men the Mechanical Revolution brought great benefit; to others, little or almost none. It

[23] Waldron and Dewhurst, *op. cit.*, pp. 11–12.

[24] The electronic numerical integrator and calculator and other "mechanical brains" have very limited organs for sensing and acting. Nevertheless, thought after thought that used to be considered thinkable only by human beings now turns out to be thinkable by machines. In a psychologically mature world, free of prejudice and greed, the robot might play a phenomenal role. See Edmund C. Berkeley, "2150 A.D.—A Preview of the Robot Age," *The New York Times Magazine*, November 19, 1950, pp. 19 ff. When will we be free of prejudice?

[25] Waldron and Dewhurst, *op. cit.*, p. 9.

should be noted that some nations, through a wise use of available resources, have achieved much wealth, a high degree of human comfort, and a good standard of consumption without a lavish expenditure of inanimate energy and without the creation of a great power–metal economy. Sweden and Switzerland have no coal, Holland has no iron, and little Denmark has neither, but who would question their great material and social progress?

The power-driven machine makes possible an economy of abundance, with more and cheaper goods and services available for human consumption and more time for human leisure. If the machine fails to bring about an economy of abundance, it is not the fault of the machine.[26] Man has learned how to harness inanimate energy to his machinery, but he has scarcely begun to learn about harnessing the machine in the best service of man. The future offers a rich life to those who achieve joy in solving or trying to solve problems.

[26] J. Russell Smith, *The Devil of the Machine Age,* Harcourt, Brace & Co., New York, 1941.

3· World Climate Regions

This book deals with industries and trade. These result from the efforts of man using earth materials with the help and hindrance of climate. The first chapters presented some of the human factors. This chapter presents one of the earth factors—climate.

I. TYPE—THE IDEA AND ITS USE

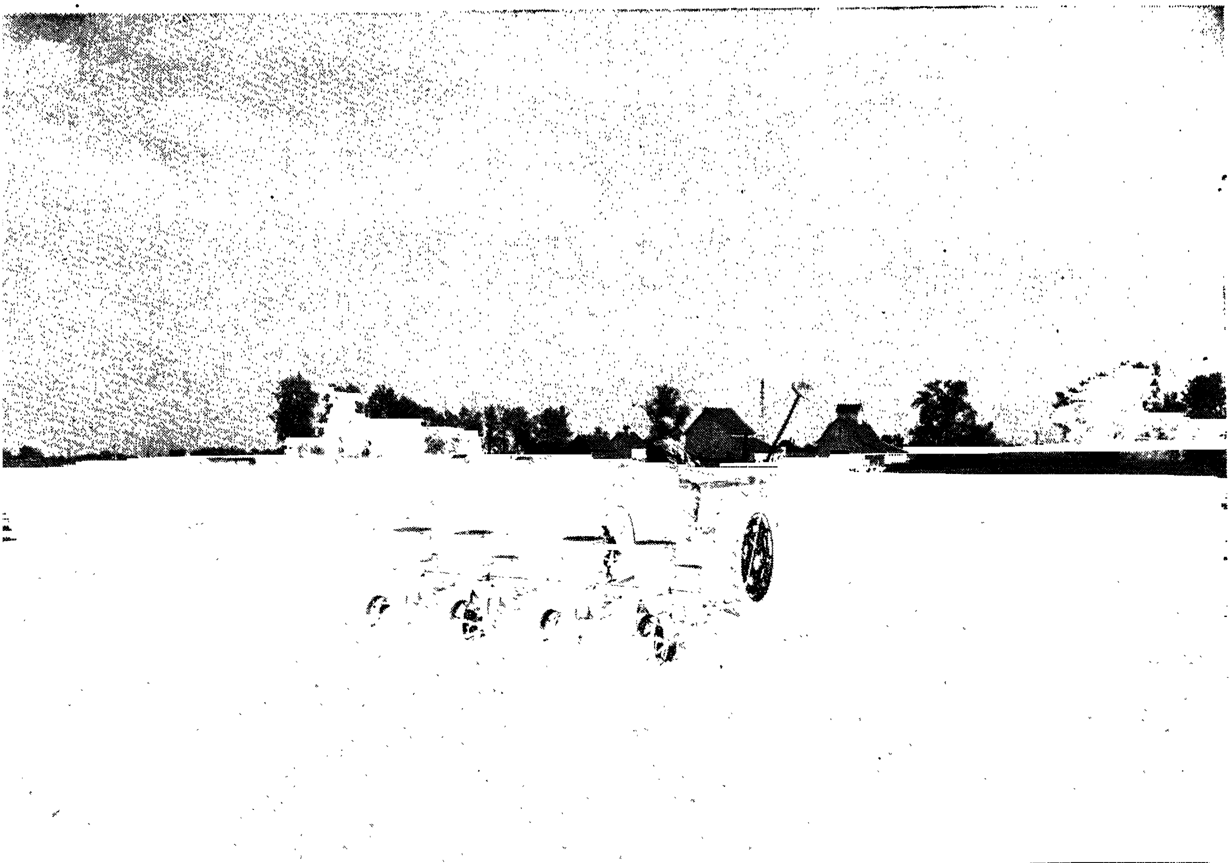
Everything that man does happens in a place, and place is a very important matter. Someone says something happened in North America. We ask "Where?" Was it on the Greenland icecap where no man lives; or the Great Northern Forest where the population is 1 per 100 square miles; or the Corn Belt covered with farms, dotted with towns, burgeoning with breadstuff, meat, milk and butter, and exporting them by the trainload; or, finally, did it happen in the uninhabited jungles of the Caribbean shore? All these are in North America.

The profound differences between these four typical regions are the result of the differing climates that occur in and exercise so much control in four different places.

Does the word "continent" have specific geographic meaning? These facts show that the term "Continent of North America" has little meaning, but "Corn Belt" and "tropic jungle" do have meaning. And what is more these are types of climate, and they make type regions. These types occur and recur in continent after continent wherever a certain set of weather conditions happens to exist. Nature has dealt out a hand of geographic cards to every region on earth, and every suite runs from deuces or worse to aces. The suites are elevation, latitude, amount of rainfall, dependability of rainfall, amount of heat, dependability of heat, and amount and dependability of wind and cloud. These interesting natural factors produce *types* of landscape and also types of most effective land use that appear in widely separated places in several continents.

For example, the colored map (front of book) shows that the climate type with mild rainy winter and sunshiny hot, almost rainless summer, called the Mediterranean climate, exists on the three shores of the Mediterranean Sea and also in southern California. The type also exists in central Chile, in South Africa, in southern Australia. Study the work and workings of man in one of these seven type areas, and you will understand the others. You will see at once why in the Mediterranean climate region in each of the six continents, men grow the same wheat, barley, and alfalfa, cultivate the same vineyards and orchards, and have the same industries of wine and fruits.

The climate type region thus becomes a very handy tool for those who would understand the earth as the home of man.



North America—Four-row corn planter on U. S. Corn Belt, flat black, rich, enough rain for 100 bushels of corn to the acre: Ohio, Indiana, Illinois, Iowa. Prime farm land, basis of power. *John Deere. (Left)* North America—Jungle in Central American lowlands. Make your farm here? The jungle will return. It always has. The water and the heavy rain will produce all the mosquitoes you need. Too bad that most of the world is not fit for crop land. *United Fruit Co.*

2. THE COTTON BELT, A SUBTROPIC CLIMATE

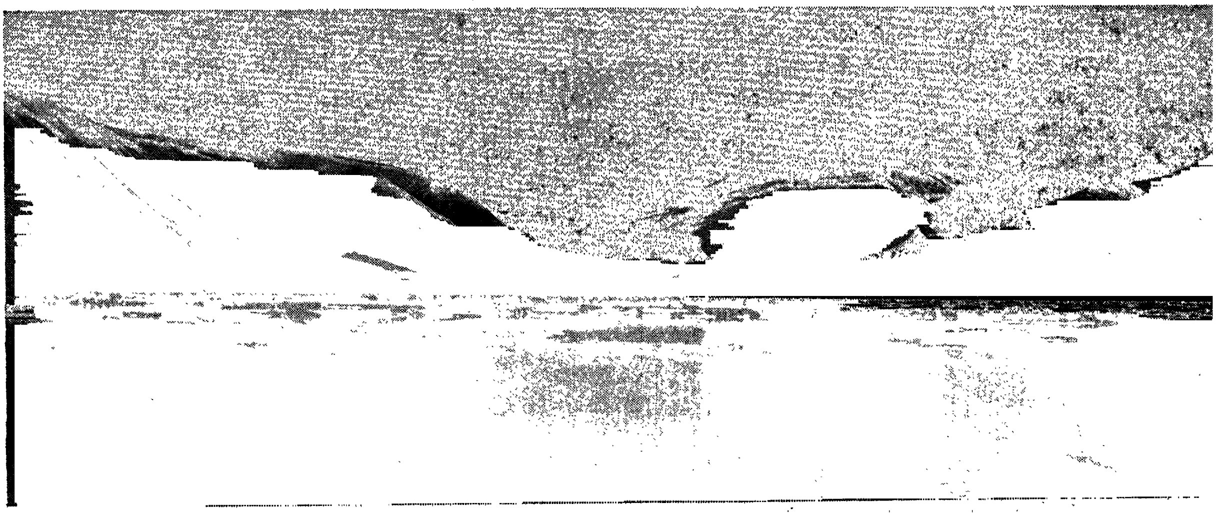
By a strange contrast, the climate forces combine to produce *dry summer* on the western sides of continents and *rainy summers* on the east sides of continents in the same middle latitude. In our country we often refer to the moist southeast as Cotton Belt, but the map shows there is one also on the east side of all continents in that latitude: China, Brazil, South Africa, Australia. The areas vary enormously in size, but they are essentially alike in what men can do with them.

The dominating economic fact about this type of climate is the summer rain. Heat and moisture together encourage plant growth—food and cotton. Therefore China has one of the three great masses of humanity fed chiefly on summer-moisture crops—rice, millet, sorghum, corn, wheat, sweet potatoes, and beans of many varieties. The man–land ratio almost prohibits much meat, although the climate encourages its production.

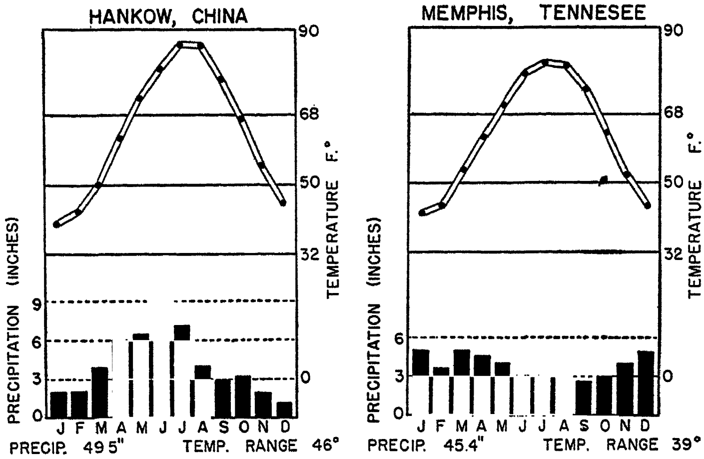
3. EQUATORIAL FOREST

As you read this section we beg you to consult often the colored map in the front of the book. Heavy red on the map shows that the equatorial forest follows the Equator around the earth. Most of the way this long belt has such continuous rain, humidity, insects, endemic disease, and upspringing jungle that man has never developed a large social unit except in Southeast Asia, where incursions of people from farther north or west have made in Java, Indochina, and India the largest monuments to man's energy that this type of climate has witnessed. The monuments are mostly in ruin, and the wide-reaching social organizations (often called civilizations) that produced the monuments are gone. Perhaps the creative energy was soaked out of man by the weather.

The cool plateaus. In tropic America the influence of the coolness and good drainage of the plateaus has caused native and European alike to flee the hot lowland and perch themselves on the highlands. Except for Panama City, the population centers and the national capitals are all inland and up—even though the highlands were very hard to reach in the prerailroad era—see Mexico City, Guatemala City, San José in Costa Rica, Caracas, Bogotá, Quito. The chief residential section of Rio de Janeiro is on the hills. São Paulo, Brazil, on



North America—Arctic. No, the voyagers in the motor boat sailing through this placid summer sea are not seeking a permanent home. On one side of this Kennedy Channel, lat. 71° N., is Ellesmere Island; on the other, Greenland. On both sides, permanent ice, covered with snow, comes close to the sea. Photo taken in early September. ***Canadian National Film Board Photograph***



Memphis, lat. 35°N., on the mighty Mississippi and Hankow, China, lat. 30° 30′N. on the mighty and terrible Yangtse, are both Cotton Belts. The Asiatic monsoon with its summer surplus rain keeps them from being identical twins. They differ but little in possible crops. Both have great capacity for feeding man. In lower middle latitude on eastern sides of continents—latitudinal twins with the Mediterranean type.

the edge of the plateau has 10 times as many people as Santos, the tropic coastal port that serves it. Mexico City and Veracruz have similar relationships of location and number.

The amazing development of these difficult plateaus, region 15 on our map, serves, by contrast, to emphasize the tropic lowland difficulties.

Tropic soils. Scientific knowledge about soil is very new. It is fast shattering a widely held belief that the tropic forest is one of the great reserves of rich land suitable for future food production.

The rapid growth, large trees, and the density of the forest in the tropic rain belts are the highest type of rank luxuriance. It is very surprising to learn that this luxuriance does not indicate great fertility. Tropic forests grow with great speed and reach great height. A vast quantity of vegetation is produced, but often the forest rests upon a base of laterite—soil composed chiefly of aluminum or iron but very low in fertility. In some places the earth has so much of one of these elements that we shovel it up as ore, haul it to the United States, Canada, and Europe, and smelt it for aluminum or iron. The elements of fertility are soluble and have been leached out by the heavy rain and the continuous heat, yet gigantic forests stand but on top of this sterility.

There is a certain resemblance here to a glass case (wardian case) the botanist puts in a window to make a little torrid zone where he can keep plants. He puts some earth and water in the case of glass—adds a few plants, and seals the case. The plants drink their little supply of moisture, exhale it, drink it again, as they take up fertility, make leaves and drop them, make seeds and die. The leaves and plants decay and feed new plants. There are records of these tiny tropic plant worlds having lived for fifty years in a sealed case. Thus fertility and moisture run round and round the cycle of life and death. The process bears a resemblance to the water in the boilers of an ocean steamer. The same fresh water is used for the boilers over and over again—boiling and condensing, boiling and condensing, hundreds of times as the boat crosses the ocean.

In similar fashion the tropic forest, like a giant wardian case, stands gigantic, complete, continuous. It uses a small quantity of endlessly circulating mineral matter, and a continual re-enforcement of carbon, oxygen, and nitrogen from the air.

The disappearing forest. Man comes with axe and fire. Man cuts the trees of the forest, burns the wood and trash, sets out a plantation, cultivates the soil. The humus decays in the heat and moisture and the rain carries fertility away. The plantation thrives a while, then fails. The forest is gone now; it cannot replace itself. Coarse grass takes its place. In all continents the equatorial forest is shrinking by this means.

The white man with his system of forest destruction is the greatest destroyer that ever

trod the earth. H. L. Shantz says that soils show that two thirds of the land where tropic forest has grown is now treeless. The native system is to deaden the trees, plant a patch of garden among the dead trees, use it for a season or two, then move on before the possibility of forest regrowth has disappeared. Thus the forest and the Negro and other tropic people have lived together for ages. The white man comes and breaks the cycle. The native with his fires has already destroyed plenty.

Plantation. If much of the tropic forest is to be preserved, tree crops must be used. Tree crops will safeguard fertility while producing food for man. In many situations there can be an undergrowth of leguminous nurse crops of herbs, bushes or small trees to catch nitrogen, hold the soil, make humus, and feed the crop trees—nuts, oils, fruits, gums, fibers, even choice woods.

There is nothing revolutionary about this idea. Note the current chief vegetable exports of the tropic-forest areas—rubber, cacao, palm kernels, palm oil, coconuts, cinchona, mango, Brazil nuts, ivory nuts (tagua, Ecuador), babassu nuts, and tea and coffee on higher lands. There might be a host of other nuts and fruits produced for export or home consumption if they should receive half the effort that has been given to the apple or orange.

In some cases, such as the coffee and cacao plantations of today, the nurse trees tower above the trees grown for crops—nurse trees furnishing nitrogen and partial shade. Perhaps a fruitful legume might be found for this purpose, either beneath or above the crop tree.

The real need is to realize that for much tropic forest land the choice is *tree crops or nothing but coarse grass of almost no value—cognales* they call such wastes of the tough cogon grass in the Philippines.

4. THE TROPICAL GRASSLANDS

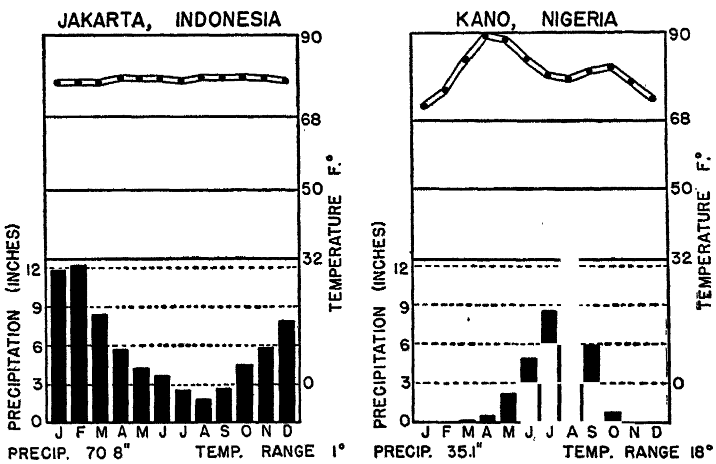
As the sun comes northward in March, April, and May, it brings with it heat and a season of rain to the land north of the tropic forest. This is reversed in the autumn as the sun invades the Southern Hemisphere. Thus the lands both sides of the tropic forest have a wide band with one rainy season: a long one near the forest, a short one near the desert. The dry season of winter is short near the forest, latitude 6° to 8°; long near the desert, latitude 15° to 20°.

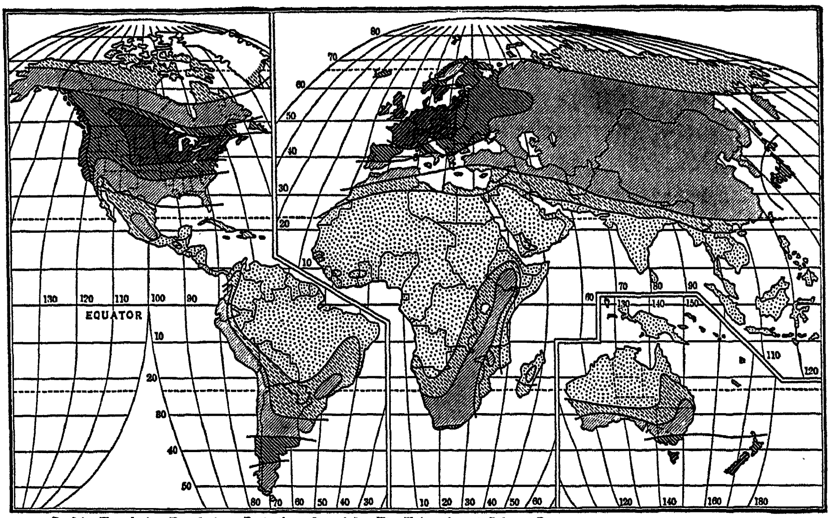
The part near the forest has clumps of trees and bush and is called *savanna.* The part near the desert has scanty grass and scattered bush and is commonly called *steppe.*

Grassland man. The African man of the savanna has done much more than his kinsman in the tropic forest. This is especially true in the Sudan, the northern grassland. He appears to benefit by the season when the humidity is not soaking him and giving him a forest to fight. There have been many grassland cultures depending mainly upon wild

Jakarta, lat. 6°S., once called Batavia, on the west end of Java gets wetted by the December-March swing of winds out of Asia toward Australia. It is relatively dried when the great summer monsoon sets in toward Asia. Enough rain to make the equatorial forest. And the temperature? Equatorial type.

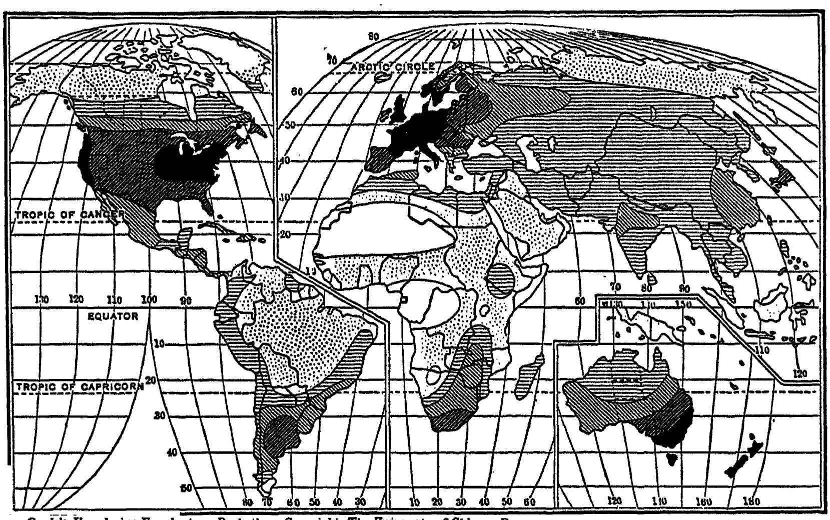
Kano, Nigeria, lat. 12°N. is type of two bands of wet and dry tropic areas north and south of equator. Compare with equatorial, also with Mediterranean types.





Goode's Homolosine Equal-Area Projection: Copyright, The University of Chicago Press.

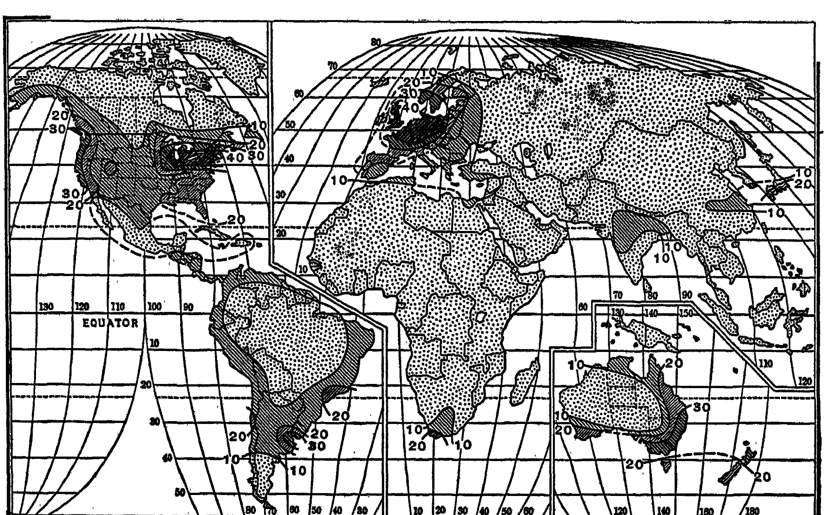
A. As a result of elaborate studies, Ellsworth Huntington published this map showing the influence of climate in making human beings energetic.



Goode's Homolosine Equal-Area Projection: Copyright, The University of Chicago Press

Very High | High | Medium | Low | Very Low

B. This map is a companion piece to the Human Energy map above it. It had the advantage to be made just before World War I had torn the world with its animosities. This map was made not by Huntington's opinion, but by the opinions of leading geographers in all countries, as to how the countries should be ranked as to the height of their civilization. This map is that pre-World War I opinion of international experts. Such a map could not have been made after 1914.



Goode's Homolosine Equal-Area Projection: Copyright, The University of Chicago Press.

C. This map, showing the percentage of occupied men engaged in industrial pursuits, has a special significance when one compares it with the maps at the top of the page. One element not shown should not be overlooked. By a strange coincidence these areas of high civilization in Europe and North America happen to have the best and most accessible coal in the world. Suppose that coal had been in the Amazon, Congo, and lower Mackenzie valleys!

ruminants for meat; some kept cattle, but nearly all grew patches of sorghum and millet for carbohydrate food and peanuts and other legumes for vegetable protein. When white men first entered the Sudan, Timbuktu and Kano were larger than the capitals of several American states today.

Unfortunately, the rainy season varies from year to year—hence an east-west band across the Sudan is known as the "Famine Zone."

In Brazil the rains are apparently even less dependable. Here primitive man did but little —and the Brazilian government has a recurring problem in feeding tens of thousands of people in seasons when the rainfall makes harvests impossible. The tropic grasslands of northern Australia have produced little for the white man except some cattle and many disappointments.

The monsoon lands and famine. India is where the tropic grassland has for ages been sufficiently in the control of man to support a large population. The Asian land mass is so great that the summer heat of the land causes the cooler sea winds to blow toward the land. See wind systems in *Goode's World Atlas.*

When the summer monsoon sets in, all southeastern Asia from the city of Bombay to the mouth of the Amur is swept by sea winds and wet by summer rains. When northern winter comes, the sun appears south of the Equator. The lands of Asia cool. Wind flows out of Asia, and India has the winter monsoon —northeast winds, cool and dry. The rainy monsoon moves along to give northern Australia a drenching similar to that which India received a few months before and will receive again a few months later.

The Indian monsoon has heat and moisture coming together. The rain falls on large areas of fertile volcanic soil in the plateau of Hindustan and on wide areas of alluvial plains in the valleys of the Ganges and Indus.

Here is the setting for another of the three great masses of humanity—masses fed largely on grains and legumes. The grasses give India far more cattle than any other country in the world, but millions of cattle keepers are vegetarians.

Famine zone. The force of the monsoon differs from year to year. Some years the rains fail to reach lands that usually have rain and therefore are populated. Consequently, the famine zone which we first saw in Africa recurs in India, particularly in the northwest toward the edge of the Thar desert. For ages men have been struck down here by starvation, hundreds of thousands at a time. Since 1900 some areas have been so desolated that there was none to bury the dead. Later their bones went to the fertilizer factory—so a native Indian official told us.

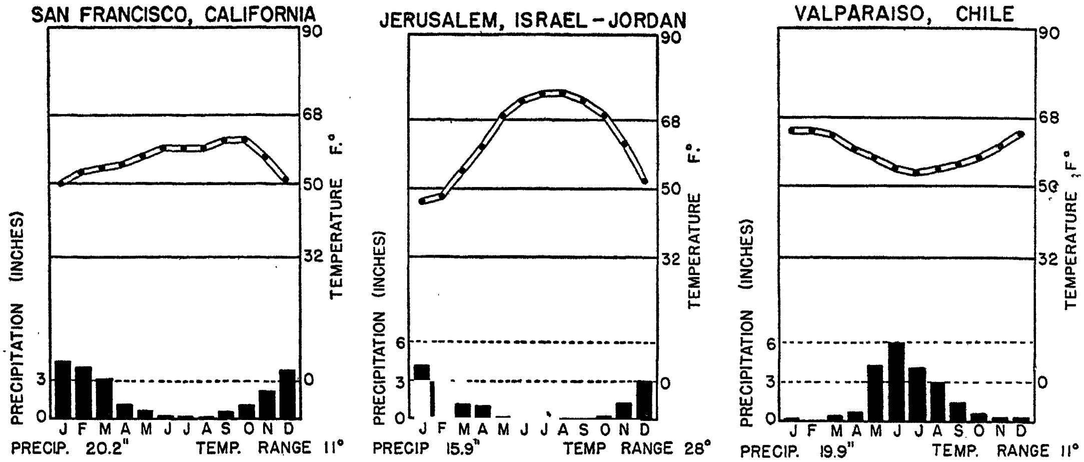
5. THE DESERT BELTS

On their northern and southern edges, the tropic grasslands merge into the desert—two desert belts that go around the world.

This land of little or no rain stretches across Africa and Asia in a most appalling waste. On the edges of the desert man is nomad, following his goats, sheep, and camels. The camel is to be seen on the Atlantic coast of Morocco, in the streets of Cairo, Baghdad, Karachi, Samarkand, Peiping, and in every town between them all. Permanent settlements of any size must be oases supported by a precious source of water—spring and wells for little oases, and inflowing rivers for big ones—for it was the oases that fed Cairo, Baghdad, Tehran, Damascus, Karachi, Kabul, Tashkent, and Samarkand.

As you look at the climate-regions map, remember that it shows relative size as accurately as can possibly be done. Areas are correct. Countries are pulled out of shape because of the map-maker's fundamental difficulty of putting the skin of a sphere upon a flat piece of paper.

Luckily North America does not have much of this desert belt, but we have aplenty—in northern Mexico and southwestern United States. In South America, Peru, Chile, and Argentina know the desert full well, as does South Africa. Australia, alas, is almost an empty shell because of the wide-reaching deserts of the interior. In the drought season desert weather advances almost to the eastern coast.



West margins of continents in lower middle latitude. San Francisco, lat. 37° 30′ beside the sea. Note very even oceanic temperature, marked rainy and dry season. Jerusalem, lat. 32° far from main ocean, cooler winter, hotter, drier summer. Why does the Bible talk so much about water, watering, and cisterns? Valparaiso, lat. 33°S. Name its winter months. Pick out the resemblances to San Francisco climate.

6. WEST-COAST MARINE CLIMATE REGIONS

In latitude 35° to 60°, north and south, the sea wind blows against western shores much of the time. These winds are moist, rain-bearing, and relatively warm—seldom much below freezing. Thus northern California, Oregon, Washington, British Columbia, and southern Alaska have what is called Mid-latitude Marine Climate. The rainy winter has much dampness and fog, a clear day is rare. There is not much snow, except on the mountains.

Unfortunately, the Pacific mountains make an eastern boundary and limit the area of usable land to a small extent, but the mountains bear the most gigantic forest in the world. The cleared land makes wonderful pastures. Only a small area is fit for grain farming. Berries, small fruits, and flowering bulbs do as well as they do in Holland.

Northwest Europe has a large area with this climate. The drenched area is small. The arable is large. This climate type includes the British Isles and the coast strip from the northwest point of Portugal to central Norway, including parts of France, all the Netherlands, Belgium, Denmark, part of west Germany, and the western lowland of Norway.

Here the farmers' chief trouble is too much rain, especially in Ireland, west England, Scotland, and Norway. Hay-making is difficult, but the pastures are wonderful. The drier parts are excellent for grain and general farming.

A climate that makes man energetic. The most conspicuous characteristic of this climate is its direct effect upon man. There are few troublesome diseases and man is everywhere energetic. The history of North-west Europe gives ample proof. Shipbuilding races in the United States during World War I found the prize winners in the damp shipyards of western Washington (see colored map). It is a great loss to the world that so little of it has this potent man-making climate.

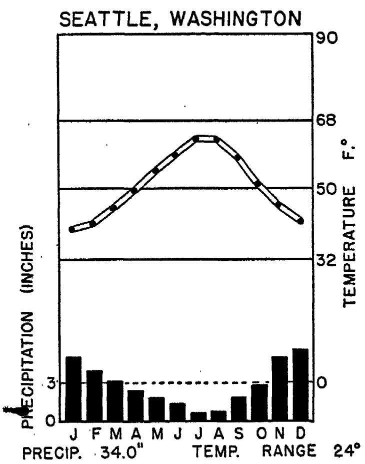
7. THE CONTINENTAL INTERIORS

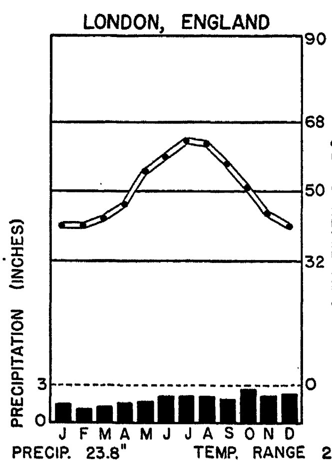
Continental interiors are often cut away from sources of moisture by mountains and also by distance, but they have the advantage of a rainy season that comes in summer (see climagraph of Bismark, N. D., on next page).

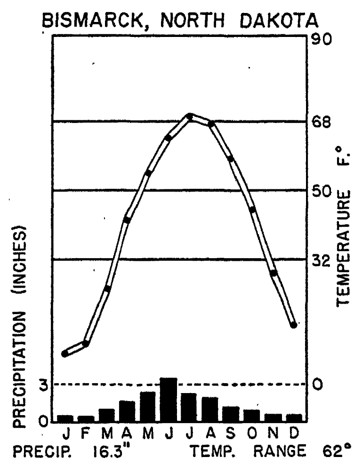
In the United States you can see the mountain influence most clearly if you ride through the Columbia Gorge (the Dalles) through the Cascade Mountains. Enter from the west and the lower slopes are green. Emerge on the east and look at the brown mountains behind you. In that short hour you have left the land of trees and farms. You have entered the treeless

land of little rain. This is the land of ranches and irrigated oases that lies east of the Cascades and Sierras. You pass eastward through many stages of vegetation, from nothing in some places to scattered grass and shrubs, short grass, long grass, and, finally, corn land in Nebraska. This land of little rain and grass and ranches occupies about a third of the United States and extends from Alberta far into Mexico.

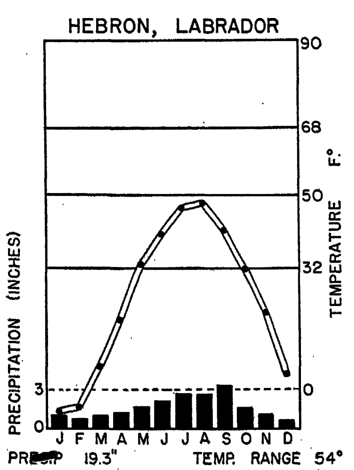
As you travel eastward you come to the area where the rainfall map (which is one of the maps on back endpaper) shows that south winds from the Gulf of Mexico bring more moisture. Grass is better; trees appear. You have come again to crop land. This band of crop land, like the ranch land to the west of it, begins in Canada and extends southward entirely across the United States. Similar bands of crop land lie between the desert or steppe and the forest in South America, Eurasia, Africa, and Australia. This band of crop land is very important for the world's food supply. In the United States, temperature and length of season divide it into three crop zones. On the south is the Cotton Belt. In the center is the Corn and Winter Wheat Belt. In the north is the Spring Wheat Belt.

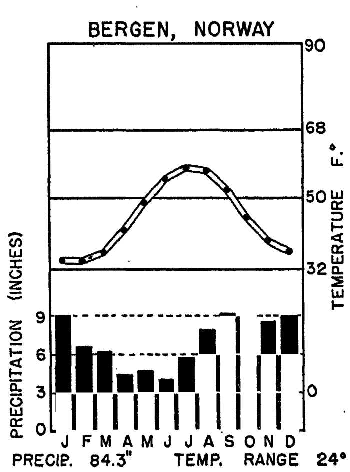






Seattle, lat. 47° 30′, and London, lat. 51° 30′, on the western shores of continents in middle latitude are temperature twins with rain every month. But look at Bismarck, N. Dak., lat. 47°, in the continental interior. Look at the summer; ponder the winter; and it is farther south than Seattle. Ponder the contrasts beween oceanic and continental climates.





Bergen, Norway, lat. 60° 30′N., on west shore of continent in upper middle latitude and Hebron, Labrador, lat. 58°N. show what prevailing westerly winds do to the two shores of the Atlantic. Compare the months with freezing temperature, and you will see why Hebron on eastern shore is so rarely found on a map. It is on the shore of an empty land, icebound most of the year. Bergen is a civilized town on an icefree harbor.

The Corn Belt. Corn is grown in many areas from the Equator almost halfway to the poles, but no other country has a real Corn Belt that is a near rival to that of central United States. The western part of our Corn Belt has a large area of very fertile and relatively level land. Much of it was originally grassland—and very fertile. The climate has enough summer rain to make a corn crop and not enough to make trouble. Droughts that make crop failures are rare, except along the western margin where drought sets the boundary.

With these advantages the Corn Belt grows more than half of the world's corn. Corn is the chief food for fattening animals. Thus the Corn Belt has made Chicago the meat capital of the world and is the leading factor in the excellent food supply of the United States.

Northwest Europe has good soil but the climate is too cool for corn. This crop has to move inland from the cool Atlantic to get the heat of the continental interior. Thus Europe's Corn Belt is in the Balkans, the Danube Valley, and south Russia; it is ended on its eastern edge by the drought of the continental interior. Irregular rainfall makes European acre yields much more irregular than those of the American Corn Belt.

The Chinese profited by the discovery of America, because it brought them this new crop which has now made North China the second Corn Belt of the world. Corn is not exported from China because the tens of millions of hungry Chinese need every kernel between the times when famine sweeps over them.

The Corn Belt of Argentina and Uruguay resembles that of the United States in quality but is much smaller. The small population enables corn to be first as an export at times.

The Corn Belt of South Africa suffers from drought. This area is small but of very great importance as a food supply for the native races who speak of corn as "mealies."

It should be noted that all the Corn Belts have a drought boundary on the side that faces the interior of the continent. This is a sinister fact. Drought boundaries are bad. They mean a zone of uncertainty.

Winter wheat and spring wheat. In most of the Corn Belts of the world, farmers grow some wheat in rotation with corn and grass. The wheat plant can prosper with less water than corn; therefore wheat has a home in the drier edge of the North American Corn Belt. It is marked as grassland 4A on the colored map in the front. Here pasture and wheat are chief rivals for the use of the land. This subhumid wheat region makes Kansas, Oklahoma, and Texas important wheat-growing states.

The same relationship of wheat region to corn region exists in Argentina and to a small extent in South Africa. Also it is very conspicuous in Europe as we shall soon see.

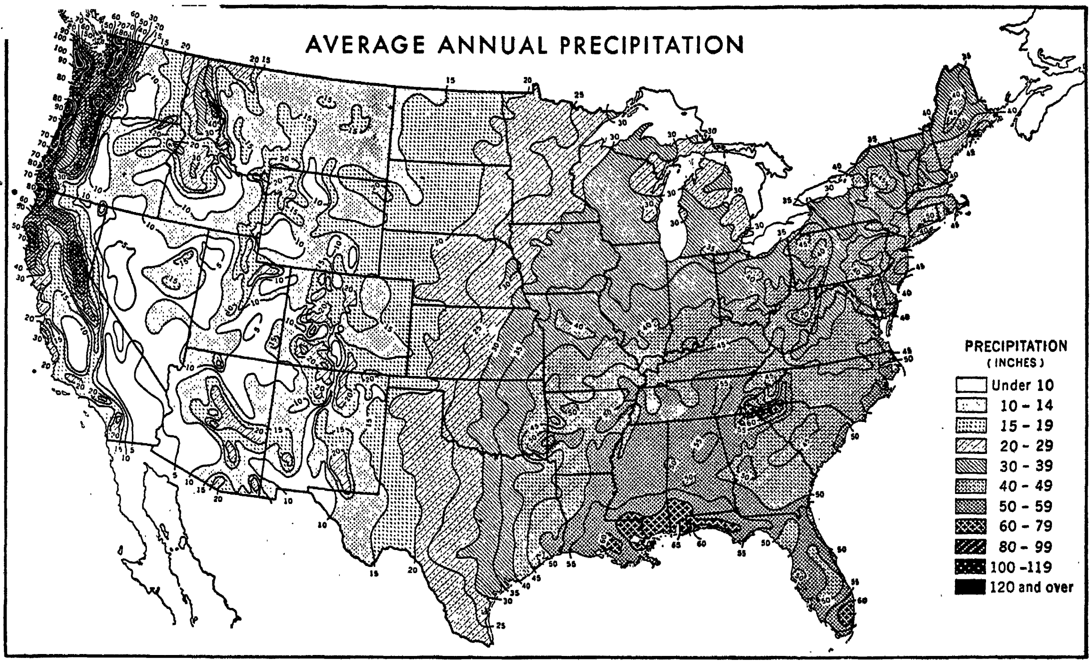
Wheat can thrive in drier summers than corn and it also thrives in cooler summers than corn. If the winter is not too cold, wheat is sown in autumn, harvested in early summer, and is called *winter wheat.* Hence the wheat of Kansas and south of it is winter wheat.

If the winter is too cold, wheat perishes if fall-sown but may be sown in spring. Therefore we have a Spring Wheat Belt in the Dakotas, Minnesota, Montana, and the Canadian Prairies. Here wheat is by far the chief crop of the farmland.

In the U. S. S. R. the corn and winter wheat area fades away and the spring wheat climate begins north of the Sea of Azov. Thence it stretches across Russia and Siberia, almost to the Pacific coast. A soils map shows that the better grasslands and the chief wheat regions follow the black-soil belts closely. These black soils are rich, soft, and very good for grain crops where rainfall permits. They produce most of this world's export wheat.

8. THE SMALL GRAIN, POTATO, AND GRASS CLIMATE REGIONS

The small grain, potato, and grass climate is marked 9 on our map. In North America, this climate region lies north of the Corn Belt, east of the Spring Wheat. In Europe it lies north of both of these. It is a land of wheat, oats, rye, barley, potatoes, sugar beets, forage beets, grass, swine, and cows.



Photograph this map in your mind. It carries a big burden of information. Look at it and then at the colored map. When you look at a dot map remember the main high and low areas and especially the transition zone as it crosses the center of the country. *U. S. Department of Agriculture*

Consider the great cities and the densely peopled farmlands that are to be found in parts of these regions, and this climate appears as one of the great climate types of the world. From the farmer's standpoint, it is too cold for corn, but excellent for oats, rye, barley, pasture, hay, potatoes, and beets. In the moisture margins of this type, the cool, damp summer just suits the potato, which here comes to its greatest service to mankind. Also most of the world's sugar beets grow in choice spots of this type region.

To appreciate the importance of regions with this type of climate, look at the map and notice that in North America it includes the Great Lakes Region, northern Appalachia, New England, and eastern Canada.

In Europe it includes nearly half of France, most of Germany, all of Austria, Switzerland, Poland, and Czechoslovakia, and parts of Hungary and Rumania, the agricultural parts of Sweden and Finland, and, finally, more than half of the Russian farmland with a big bite of Siberia. In America much of the land with this climate is glaciated and rough, whereas the European part has a better surface and supports heavy agricultural populations over large areas.

9. THE GREAT NORTHERN FOREST

Both North America and Eurasia contain a northern forest of great extent—marked *7* on the colored map. These regions are rivaled only by the desert in area. Unfortunately, they resemble the desert in their nonagricultural quality. Late spring frost, early autumn frost, and occasional summer frost make their southern boundary. This is also the northern boundary of the Spring Wheat Belt and the Small Grain and Potato Belt. North of this frosty boundary the forest holds sway. It stretches across North America at its widest part, from near the coast of the Bering Sea to Newfoundland. It is even wider in Eurasia—from the shores of the Atlantic across Scandinavia and the vast Soviet Union to the Pacific.

In both hemispheres the Great Northern Forest has long been the home of a very scanty population of wandering hunters. In the commercial era the hunters became sellers of fur.

Now in the era of the airplane these vast and dreary stretches of forest, based on very ancient rocks and dotted with lakes and bogs, are being most eagerly searched for the many valuable minerals, such as those that have helped to start a Canadian boom. Unofficial reports or rumors credit the Russians with similar finds.

Much lumber is produced along the southern edges of these forests. These regions are a possible forest reserve for a timber-hungry future. Unfortunately, the tree growth is slow. A wide band at the north of this region will not make a tree of saw-log size, and the mossy ground cover is nature's prescription for a dry summer fire that smolders and creeps and creeps, then flares and creeps again, perhaps until cold weather comes—a terrific handicap.

10. THE TUNDRA AND THE ICECAPS

The Great Northern Forest thins out to worthless scattered treelets and finally gives way to the Tundra, with its surprising cover of grasses, flowers, shrubs, moss, and plants producing edible berries. This vegetation manages to live in the foot or two or three of earth that thaws each summer above permafrost, the permanently frozen layer that is often hundreds of feet deep and surrounds the Arctic Ocean.

This is the land of the caribou (reindeer), the wolf, the bear, the fox, and of migratory birds. The Eskimo lives by hunting and fishing along the American shores, and in Eurasia the Lapps and other peoples have followed their herds of reindeer (tame caribou) for many centuries. Petroleum has been found in the Alaskan Tundra, but the mineral resources are largely unknown in this hell of cold in winter and hell of biting insects in summer. We do not personally like the Arctic, but our valued friend Stefansson likes it after years of thrilling exploration.

In Greenland and Antarctica the Glacial Epoch still holds sway with its covering of ice, often called icecap. Several hundred thousand square miles of ice cover most of Greenland. Antarctica is almost completely covered by an ice sheet about as large as Europe. These accumulations of solidified snow seem to have no economic value. There is no evidence that men ever made homes in Antarctica. Several women have flown over parts of it, but Admiral Byrd said in 1952 that he was not sure that any woman had ever yet passed a night on Antarctic land (or ice).

11. WHERE CAN CIVILIZATIONS ARISE?

The world industries that this book attempts to describe and explain are a joint product of soils, minerals, climate, and the work of man. The work of man means the expenditure of energy: muscle energy, brain energy, and—in most recent days—inanimate energy. But it takes brain energy to operate inanimate energy.

All who read this page know that different weather conditions give you different feelings toward work or strenuous play. Here is one of the keys to civilization. Earth gives resources, but *weather* holds us back or urges us to work. Yet more, *climate* often *compels* us to work or STARVE and to save or STARVE.

4· The Place and Nature of Agriculture

Food is man's first necessity. Directly or indirectly he gets it all from plants or through the animals and fish whose food supply traces back to plants, often in its microscopic forms.

The land feeds us except for about 2% of our protein: that we get from the sea. Agriculture, the food industry, also clothes us, except for fabrics of rayon and other synthetic fibers and the synthetic substitutes for some of the uses of leather.

Agriculture is a child of chance because crops must grow subject to the qualities of soil, the changes of temperature, wind and storm, drought and rain, insects, and bacteria that make rusts and blights. Agriculture becomes a scientific industry because of the need for fitting the characteristics of both plants and animals into the conditions of nature and the needs and whims of man. This dependence on the whims of nature and the needs of man is true in all stages of agriculture, or of subsistence from wild plants.

1. THE FOOD GATHERER

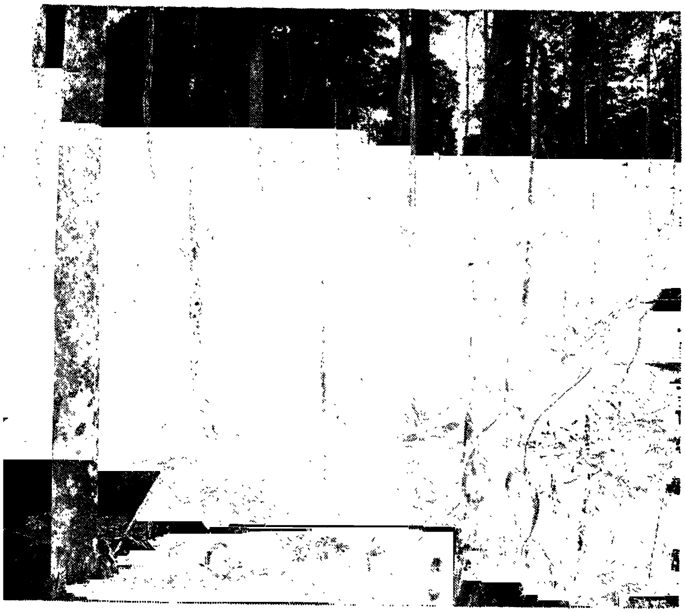
Much the greater part of his ½ million years (or is it a million or more?) man has lived a life that the anthropologists call *food gathering*. The food gatherer lives on the free products of nature—anything digestible that he can find, catch, or dig—fruits, seeds, nuts, leaves, stems, roots, the bodies of animals, fish, bird, reptile, or insect. Everything that was digestible served to help to meet his primal and unending need.

This type of existence still persists in remote corners. Anthropologists come back with reports of it in the wilds of Amazonia, Malaya, and other places. The Eskimo is one of its higher types. Some white man's equipment secured by trade has mitigated his labor, but in most cases he is still a food gatherer.

2. PRIMITIVE AGRICULTURE

Planting of seeds and the cultivation of plants was a great improvement over finding wild things, but the planting stick and the stone hoe made it a laborious kind of existence in the absence of metal tools or beast of burden. Hand agriculture without metal could not produce food to feed animals over a cold winter, but it did permit small groups of people to live near patches of hand-grown corn, squashes, beans, wheat, and we know not how many other plants. A bulletin of the Smithsonian Institution lists 1100 plants used in some way by the American Indian.

The natives of the United States were living by this primitive Stone Age agriculture when Europeans landed there. The untamable character of the wild animals of North America prevented the Indian from having a beast of burden to pull a plow or be a source of milk and meat. Therefore his population had to be



The tropic forest garden. Congo forest: rice, cassava, banana, corn. ***H. L. Shantz***

scanty, depending upon wild animals for meat and leather. The irrigated fields of hand-grown corn in Arizona supported villages in protected places.

Recent study of 30 feet of accumulations on the floor of a cave in northern Iran suggest that wheat was cut with stone-edged sickles about 30,000 years ago.

It still continues. A Stone Age agriculture, without metal, plow, beast of burden, or trade with the white man, still continues in remote corners. Examples have been recently reported in northern Australia, in the forests of southeastern Asia, and in Brazil.

The primitive farmer adds iron. The French geographer Jean Brunhes gives a vivid description of Stone Age agriculture among the African forest villagers as he saw it 50 years ago. When the villagers wanted a new garden, they went into the forest, cut out the small trees or vines, girdled the larger trees. Fire in the dry season destroyed the burnable material and released some plant food in the ashes.

These primitive agriculturists (patch farmers) have made iron and had iron hoes for generations. They planted bananas, cassava, yams, sweet potatoes, beans, corn in this deadening. It seems that the American Indians' maize entered the Congo forest before we did. This forest garden gave good crops for two or three years, then yields declined. The people abandoned it, and took a fresh site until all the suitable land near the village had been used. Then they moved the village.

Your ancestors and ours lived this way. How long? No one knows—perhaps many thousand generations. The system was almost world-wide in forest lands and good grasslands, with planting stick and hoe of stone or shell, rarely and lately of metal.

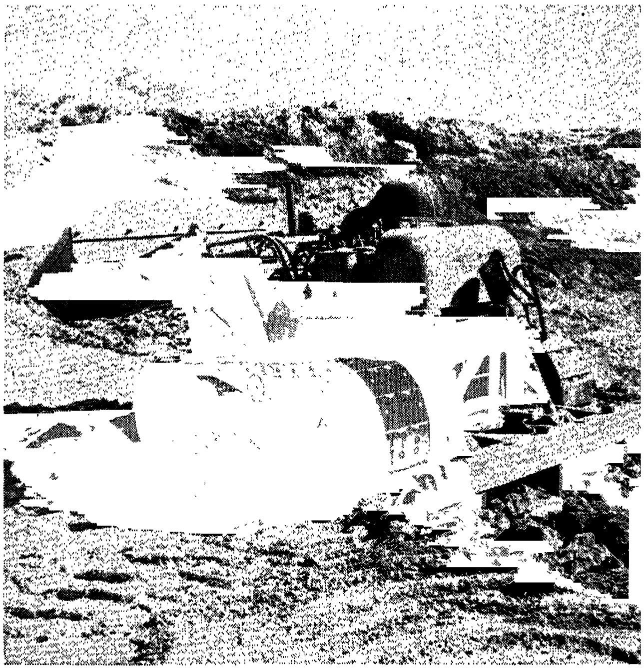
3. MODIFIED PRIMITIVE AGRICULTURE

Add a few trade items—iron pot, knife, needle, thread, cotton cloth, perhaps a hoe, and you can find millions of people living by this primitive agriculture (slightly modified by a little trade) and a few smaller domestic animals, chiefly chicken, goat, pig. You can find them in the tropic-forest areas of all continents in which tropic forest exists.

We have seen forests of pine in the Dominican Republic which are said to have grown up after abandonment by the local agriculturists of the kind just described. In that country such a "farm" is called *conuco*. The conuco is a patch farm, with crops and system almost exactly like that described by Brunhes except for the small trade with regions overseas. You can see it today if you will take the trouble to go back a few miles from a truck road in many parts of Latin America from Mexico to Paraguay. It is called *milpa* in Mexico and Central America.

The house of the *conucero* (patch farmer) usually has grass walls and a grass or palm-leaf roof. The family grows all its food, and purchases are limited to cooking pot, machete, cotton cloth, fish hooks, needles, thread, and—luxuriously perhaps of late—a little hand sewing machine.

A few donkey loads of tobacco, charcoal, firewood, or vegetables for town, or perhaps a few chickens furnish part or all of the very small cash supply. There may be a chance for a few days at cash wage helping with some



(Left)* The African woman makes a garden. *H. L. Shantz* *(Right)* This 20th-century earth breaker sticks steel claws down and shatters 18 inches of earth. Plows with horses do 6 to 8 inches. The deep shattering opens a new epoch in farming. This machine can pick up 40 cubic feet of earth in the carrier at front and dump it where desired. *Allis-Chalmers Manufacturing Co.

modern enterprise. When the soil of the garden is exhausted, the tillers of conuco or milpa move as the African forest people do—and in some parts of the Dominican Republic—and pine forests grow up in the erstwhile gardens. This is an almost world-wide survival, slightly modified, of the prehistoric primitive agriculture that was widely spread over temperate and tropic lands for the many thousands of years during which man had to depend upon his own muscle.

4. THE DOMESTIC ANIMALS MAKE AN EPOCH—A LONG ONE AS WE COUNT TIME

We enslaved rival species—the domestic animals. This enabled man to make larger-scale conquests of nature and increase the food supply. When the domestic animals became our slaves and worked for us we could operate in larger numbers, have larger human groups and do bigger things. The ass (poor butt of millennial jokes) seems to have been the first of our four-footed slaves, followed by the real hero (measured by service to us)—*bos domesticus,* the stupid common cow—and her son, the patient and long-suffering ox. The ox and cow worked with yoke on head and shoulders and pulled the plow and cart for many centuries. The more expensive horse came late. His head, neck, and shoulders are not fitted for the yoke that fits the ox and cow so well. The horse collar that does fit the horse's shoulders is a comparatively recent invention. The Romans operated without it. Someone seems to have achieved it in France in the ninth century A.D.[1] That horse collar made horsepower cheaper than slave power and slavery gave way to serfdom.

The ass, ox, horse, and mule (with horse collar) permitted the creation of the real farm that could produce enough food for the family,

[1] J. Russell Smith, "Grassland and Farmland as Factors in the Cyclical Development of Eurasian History," *Annals of the Association of American Geographers,* September 1943, p. 151.

It is possible, even likely that the dog, as assistant hunter, was man's first helper.

feed the beasts of burden, and sometimes yield a small surplus to sell. This gave us the agricultural village or the isolated farm (something of a rarity from the statistical standpoint).

Societies resting on this base of muscle power supported the men of Ur, Confucius of China, Darius of Persia, Alexander the Great, Caesar, Charlemagne, and Columbus. With the aid of the compass, the culture with this food supply crossed the Atlantic, found Indian corn (our corn), and supported the colonies and the communities that George Washington led to political independence.

During this period between the Assyrian cultures of Babylonia and George Washington, we added invention of movable type, gunpowder, and the mariner's compass, but there was no invention of stupendous importance to increase man's food supply. For 5000 years, perhaps more, man plowed with ox, donkey, mule, and—after 900 A.D.—horse (if he had one). The woman spun, wove, and sewed by hand. Mankind did a little hauling on carts or wagons over roads which we would now think were next to impassable.[2]

Muscle and the river bank. Transport was especially weak during this historically long (racially short) period when food production depended on the muscle of man and his beasts. Its limitations are shown by the distribution of population at the founding of U. S. government. Cart and wagon hauled wheat, meat, whisky, fur, potash, ~~and lumber~~ to the river bank. Thence flatboats that could not go upstream floated the freight down such streams as the Susquehanna, Potomac, Shenandoah, James, through long reaches that have seen no craft but the sport fisherman's skiff since the coming of our short canal era and the railroad, which followed it so promptly and demolished it so quickly.

In 1797 a man named Gruber started publishing an almanac at Hagerstown, Md. It had a set of woodcuts showing the farmer's year and the methods of the day. Let's call him the underdeveloped farmer. In *March* 1797, the year in which George Washington retired to the delights of his farm, Gruber's farmer began his year by building fences. All fences there were of stone or wood. Note oxen, the straw eaters.

5. THIS DOMESTIC ERA

That river-bank era required good climate, good land, and forest to make the almost self-sufficient farm and the almost self-sufficient community, such as those of the Americans who signed the Declaration of Independence. A Massachusetts pamphleteer gives us a telling snapshot of this period of human history.

A Massachusetts farmer's advice. During the disturbed period of our Confederation, 1783–89, there was much complaint of hard times. A thrifty Massachusetts farmer said these complaints were foolish. The real need was that people should be thrifty and do as he did. He wrote a pamphlet telling how he supported his family.

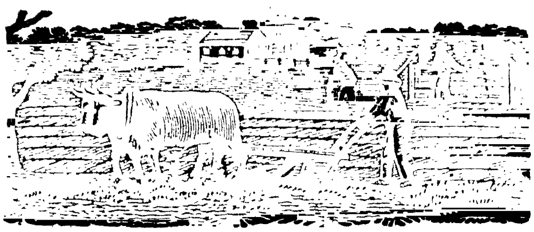
With the wheat and corn and buckwheat that grew in his field he furnished the family bread. The chickens, pigs, sheep, and an occasional beef animal that he slaughtered furnished the meat. His garden furnished all the vegetables and his orchard and fencerows, all the fruits, many of which were dried for winter use. The farm produced the family food. For clothing, his wife spun the wool which he sheared from the sheep; and she made linen from the flax that grew in the corner of the garden. The family's shoes were made from the skins of the meat animals tanned on shares by the local tanner. Thus was the family

[2] See accounts of travel, Philadelphia to Boston or elsewhere, in the colonies in the Revolutionary period. Exception should be made for Roman roads that served a small area for a short time. It should also be noted that the chief service of the Roman roads was military and political—to let the legions get there quickly and crush any rising independence.

important marketable product support people in great comfort in places that in 1776 had almost no trade. Before the coming of the railroads, level treeless plains in the continental interiors were almost useless to man, and he clung to the waterway with trees along its banks, no matter how fertile and productive the treeless plains were. The first settlers of Illinois shunned the rich, level, treeless prairies and fought stumps and hills on the forested areas near the streams.

The problems of shelter and fuel were perplexing without trees or coal. About the only way that this difficulty could have been met would have been the one practiced by the people of northern China. They have succeeded in living in the old-fashioned way on such plains by building mud or unburned brick houses covered with thatch or tile and using for fuel the coarse stalks of a kind of millet which they grow as an annual crop for this purpose. Owing to the scarcity of farm-grown fuel supply they must economize severely, and therefore make no attempt to heat their rooms. Instead they wear quilted cotton or thick sheepskin clothing, and sit by day and sleep by night upon a low, hollow brick platform continually kept warm by a small fire of millet stalks smoldering beneath it. The Caucasian American did not copy or develop this type of grassland existence.

Significance of easier access to market. World commerce in the Machine Age enables western peoples to live very differently on treeless plains. The vast treeless plains from Texas to Manitoba and westward to the Rocky Mountains have become the home of tens of thousands of comfortable farmers and townsmen, who bring their wood, coal, gasoline, furniture, and most of their food hundreds of miles and pay for it with their wheat and corn, cattle, sheep, and wool. They ride in automobiles and many live in houses supplied with bathrooms and electric lights.



***April,* plowing. The County Agent tells us that he knows no oxen at all in that county today: many tractors.**

This fact, that a community can arise wherever one salable product can be produced in dependable quantity, has multiplied the areas that commercial man can use and makes it necessary to examine a region very closely to see its possibilities.

Because of the fundamental character and enduring nature of agriculture, *if soil be preserved,* one of the first things to note in the appraisal of any region is how long will its people keep the soil that feeds them and gives them something to sell.

7. MACHINES MAKE A WORLD MARKET

The short period 1825–1900, the period of a man's lifetime, witnessed the most startling revolution that has ever been seen in man's economic affairs in so short a time. This revolution had three bases: (1) the steam-driven factory machine, (2) steam transport. By 1825 the steamboat had captured the rivers, given the Mississippi valley boat traffic both downstream and upstream. The steam engine in the iron ship soon captured the sea trade, while the steam locomotive was carrying settlers inland on six continents and bringing their produce down to the seaports. (3) This new farmer on the new lands, like the older farmer on the old lands, had his powers multiplied by the horse-drawn reaper, mowing machine, hay rake, and steel plow.

The period 1900–55 has witnessed another revolution almost as great, perhaps quite as great as that of 1825–1900. This last revolution, now in full swing, was based on: (1) high-speed steel cutting tools in the machine shop and its children: the automobile, truck, and airplane; (2) electricity and its children: power-dispersal to factory and home, widespread telephone, radio and television, and refrigeration.

The astonishing results of the Diesel engine on farm and elsewhere may almost be called revolutionary.

Since 1900 the efficiency of the people using these devices in factory, transport, farm, and home has been increased by an amazing and endless volley of new knowledge and exhortation coming out of engineering schools, research laboratories, U. S. Department of Agriculture, state departments of agriculture, and firms with something to sell.

The Age of Machinery has opened the continental interiors, made the city era, and permitted great increase in population.

8. WORLD WAR II AND THE AMERICAN FARM BOOM

In the spring of 1945 there came a news release from official sources to the effect that there were 5 million fewer people on farms in the United States than in 1940 and that the farm product had increased 35%.

What had happened? What caused this explosion of production? The U. S. government had guaranteed prices—good ones. The American farmers could plan, plant, extend crop areas, and harvest without the fear of the glutted market that had haunted them so repeatedly, almost so constantly, since machinery had lifted them out of the domestic epoch. They could and did buy fertilizer, buy new machinery, pay high wages—produce. For the first time in their lives all of them dared produce a lot without fear of the hidden enemy, the glut.

In the old era of domestic agriculture, good harvests meant prosperity. The farmer had the *goods he needed*. In the new commercial agriculture, prosperity depends upon good prices and something of a crop, so that the farmer may get the *money he needs*. An extra large crop has come more and more to be a calamity to the producer and no particular advantage to the consumer.

The statistics on almost any American farm crop, such as corn, potatoes, or cotton, show that before 1940 the farmers as a whole received greater income from a small crop than from a large one. In 1926 about 2 or 3 million bales of cotton went unpicked in this country, and the rest sold at the price of picking. In the same year some 20 or 30 million bushels of apples went unpicked, while 120 million bushels sold at the cost of picking or less.

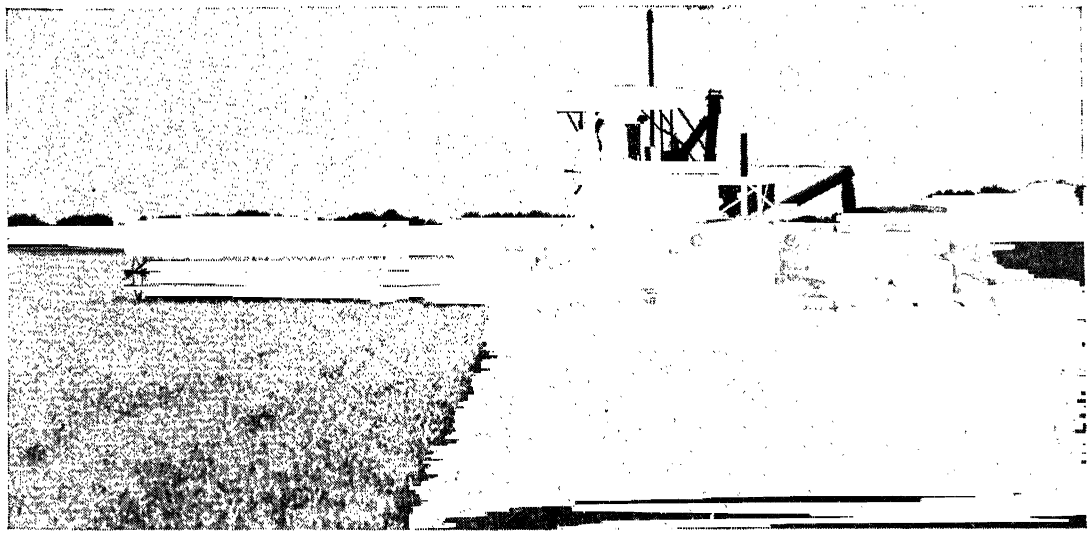
There is a glut of some truck crop in some of our city markets almost every month of the year. Continuous surpluses are sure to bring ruin to thousands of producers. Hence one of the great objectives of American producers in all fields is the maintenance of relative scarcity.

In most of the period between the two world wars, American agriculture was unprosperous and depressed at a time when producing capacities for both food and factory stuff were greater than ever before (see Fig. 64).

The Machine Age commercial farmer is dependent on *price* to a degree unknown in the domestic era. He sells one or two or a few things and buys a host of things that Domestic Era Grandfather went without or produced on the farm. Auto, truck, and gasoline have replaced the horse. The horse was often home-grown and usually home-fed. The cash cost of machines and gasoline on a given farm today may equal the gross cash income of the same farm in the 1890's.

A glut and price drop such as that of the 1930's (Fig. 65) would stop tens of thousands of American farmers almost as a blown tire stops an auto. These blown-out farmers could not buy or operate the machines. They

May, washing the sheep to clean the wool, also shearing.



The wild horse of the plains harvests, thrashes. With this machine and some gasoline, one man can harvest and thrash as much wheat as a small army could in the days of George Washington's reaping hook, oxen, and flail. ***Kansas Agricultural Experiment Station, Manhattan, Kans.***

could not go back to the horse. The horse is dead.[8]

World War II showed us how the Machine Age can produce. We put millions of men into armed services. Other millions of men and women made munitions and supplies to pour into the insatiable maw of Mars. We equipped our own armies, navy and air force, sent shiploads of everything to our allies and, would you believe it, the American farm laborer and town workman raised their wages and raised their standard of consumption at the same time. They had better food, better clothes, new washing machines, refrigerators, plumbing and gadgets without end, and millions had automobiles that would run.

After this we gave away to foreign nations billions of dollars worth of goods through Point Four and other programs.

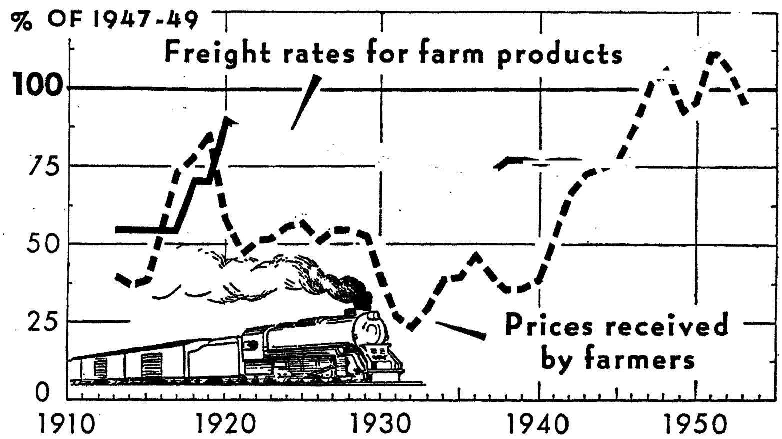
June, **hay: scythe and hand rakes. The grass is pitifully short, no superphosphate then.**

9. THE U. S. GOVERNMENT MEETS THE GLUT BY STORING CROPS

Meanwhile there was that government guarantee of farm prices, and its result in surpluses began to appear. To uphold the price, the U. S. Department of Agriculture bought and stored wheat and corn, cotton, and peanuts until the scarcity of storage space became a problem. Finally the Secretary of Agriculture bought and stored butter and more butter, hundreds of millions of pounds of it. The butter question became most pressing. The government could not sell it. We could not give it away at home or abroad because of the market disturbances that would result. We even stored it in caves. And so at this writing, August 1954, the butter continues to pile up, and Congress continues to borrow money to pay for it and thus prevent collapse of farm prices—propping the economy.

[8] In 1920 we had 25,000,000 horses and mules. In 1953, 5,636,000 of which 3,870,000 were horses. If an edict went forth on January 1, 1955, to put agriculture on horse-mule basis, it is doubtful if the most strenuous efforts at horse-building could produce 1 million colts in 1956, and they could begin work in 1958. In the meantime conditions of famine or near-famine would arrive, unless we could import from some tractor land. We would still be short of horses in 1966. We can't go back. We have given hostage to machinery and petroleum.

RAILROAD FREIGHT RATES AND PRICES RECEIVED BY FARMERS



The farmer has to take it. The railroad does not share his trouble. See Interstate Commerce Commission and the railway unions. *U. S. Department of Agriculture*

The farm bloc justifies. The Farm Bloc in Congress justifies this by pointing out that the other groups in the U. S. economy are already propped.

(1) Most manufacturers produce on order. If they cannot get orders they shut down and turn the workers out on the public (unemployment relief).

You can see the effect of this on prices by checking the price of automobiles and the production by quarter-year periods or yearly periods. Production fluctuates wildly; price does not; but the plant shuts down. See Automobile Chamber of Commerce, Detroit, Mich., for figures.

(2) Organized labor has contract rates—work or lay off on relief if necessary. Unorganized farm labor gets much less.

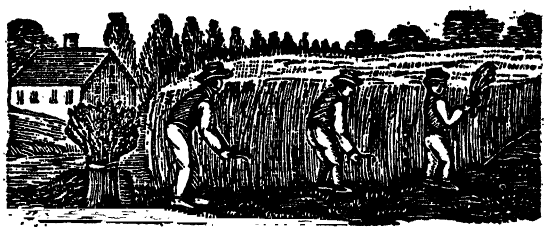
(3) Transportation agencies have rates fixed by legal regulatory bodies, and in some cases it is a crime to cut the rates (Fig. 65).

(4) Banks do not reduce the price of money (interest rates) for the little fellow when business is dull. They let the money lie.

The farmer cannot save himself by any of these means that others have used. He cannot produce on order; the weather is too uncertain. He is always producing for future markets, often several years in the future (apple trees, orange trees, horse, dairy cow, dairy barn). He cannot shut down as the others do, or hold up the price. Therefore, the glutted market is the ever-present terror of the U. S. farmer in normal times. When farm prices are bad the farmer usually has only two recourses: grow more of the crops he does grow or shift to another crop. Both increase his neighbors' glut as well as his own.

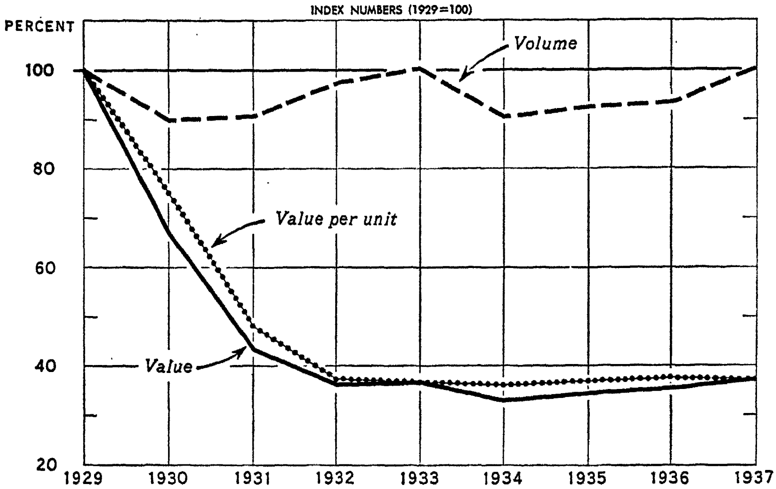
Farmers are so scattered and so numerous that they cannot organize, go on a strike and hold up the public, as labor and money and trusts have often done. That is why the farmer, the peasant, the man with the hoe, has been at the bottom of most cultures for ages. That is why so many U. S. farmers went bankrupt in the 1930's (Fig. 65).

As the depression of the 1930's dragged on, the U. S. government attacked the farm situation by trying to limit acreages. While experience with this difficult problem was accumulating, we got into World War II with its insatiable demand. To get production the U. S.



July, **cutting wheat, reaping hook or sickle as in ancient Egypt.**

RAW COTTON AND LINTERS: VOLUME AND GOLD VALUE OF WORLD EXPORTS



Dynamite: These lines record an explosion that ended the era of freedom to grow and sell major farm crops as grower chose. Imagine, if you can, the results that would follow if the cash results of your year's labor or that of the enterprise of which you are a part declined 62% in 3 years and then hung at that dreadful point for 5 solid years, and, if you sought another job, there wasn't any.

This brought attempts at acreage control and price control, of which you will not see the end in time of peace. World War II gave a respite, but that has ended. World export of raw cotton and linters, here shown, can be taken as the type for commercial agriculture. Wheat graph is almost identical. _U. S. Department of Agriculture_

government guaranteed prices and started the farm boom of the 1940's.

This World War II price support and its postwar continuation was the longest period of guaranteed good prices the American farmers ever experienced. It made a social revolution in agricultural U. S. Their spokesmen say it should continue. They say the public pays the laborer high, the manufacturer high, the banker high, and the farmer also must be paid high like the rest, or the glut will smash him again. He can't check glut alone as the auto makers do. Therefore he needs aid from Uncle Sam.

The farmer points out that this is only fair. He calls attention to the millions Uncle Sam hands over as subsidies to steamship lines, to air lines, and for building airfields. On August 4, 1954, Congress approved spending $91 million to deepen the Delaware River to Trenton, to serve the United States Steel Corp.'s new Fairless plant. And war industry plants have had quick depreciation tax write offs.[4] Randolph Paul, author of "Taxation in the U. S.," says that this item in a tax bill before Congress (July 1954) will cost $40 billion in seventeen years. We need help too, says the farmer.

August, dump cart: manure from barnyard; still the oxen.

A committee of Congress says the farmers need help. The agricultural committee of the House of Representatives reported to the House, August 2, 1954, that food prices had fallen 20% at the farm and that "consumers had benefited very little in the retail market."

The study showed that out of each dollar spent by the American housewife for domestically produced food, 56 cents now goes for processing, marketing, and transportation charges. "The farmer receives 44 cents. Of this 44 cents, approximately 30 cents go to purchase tractors, trucks, plows, gasoline, fertilizers, and other supplies required by modern farming," the report continued. "Thus the farmer and his family have about 14 cents out of each consumer dollar spent for domestically produced food for their work and their investment."

In the case of wheat, the report said that in January 1948 the farm price of wheat reached

[4] During World War II the United States Steel Corp. built a $200 million steel plant for the U. S. government at Geneva, Utah. Shortly after the war it was sold to United States Steel for $47 million. The list of government favors and aids to industry would fill a book.

a peak of \$2.81 a bushel. The average price of a one-pound loaf of bread then was 13.8¢. The farm price of wheat now is \$1.91 a bushel "yet the average price of a one-pound loaf of bread has increased to 17 cents," an increase of 23% while the wheat farm price declined 32%.[5]

It painfully appears that, despite government price supports for farm crops, the compact and organized city groups are getting ahead of the widely scattered farmers. Must they sink again as in the 1930's?

The problem of maintaining relative scarcity. Here you see perhaps the greatest unsolved economic problem of the Machine Age. Abundance is the Devil of the Machine Age. We of the West can produce abundance but we have not learned how to distribute it. That is the problem. It is far from being solved in factory or field, and especially in crops.

The cure now proposed for the U. S. situation is compulsory reduction of crop acreage, and therefore of production.

We have illustrated this discussion largely with current and recent U. S. data, but government control of agricultural production to control price is centuries old and almost worldwide.[6] In 1629 the Virginia colony tried it with tobacco, and there have been scores of trials in many lands from that day to this. Next in size to our own attempts was Brazil's struggle with the coffee crop and price—an instructive story. There have been international agreements in this field, especially with sugar, covering many years, and a recent agreement among wheat exporters.

This government control problem ranks almost with climate as an influence on crops and trade. Look at Fig. 69 and notice how our success with high price reduced our cotton exports in the 1930's. Other nations grew it instead. In 1954 new government storages were being built for the 1954 crops and the impossible piles of butter and wheat grew higher. We think it is safe to predict that the readers of this book will witness much political struggle about the operation of U. S. price support for the farmer and, as a consequence, increasingly rigid control of production to keep the surpluses down. We have here, for the life of this book and longer, something in the nature of a permanent problem that will affect several of the major industries described in this book. World War II merely gave it an intermission.

10. WHY NOT EXPORT THE FOOD?

The strange exports of meat. In past decades the United States exported vast quantities of beef, pork, and lard. This export has almost ceased. Consider a bushel of grain. It may go directly to Europe to feed man or beast, or it may stay in this country and produce four or five broilers (chickens) or a few pounds of beef or pork.

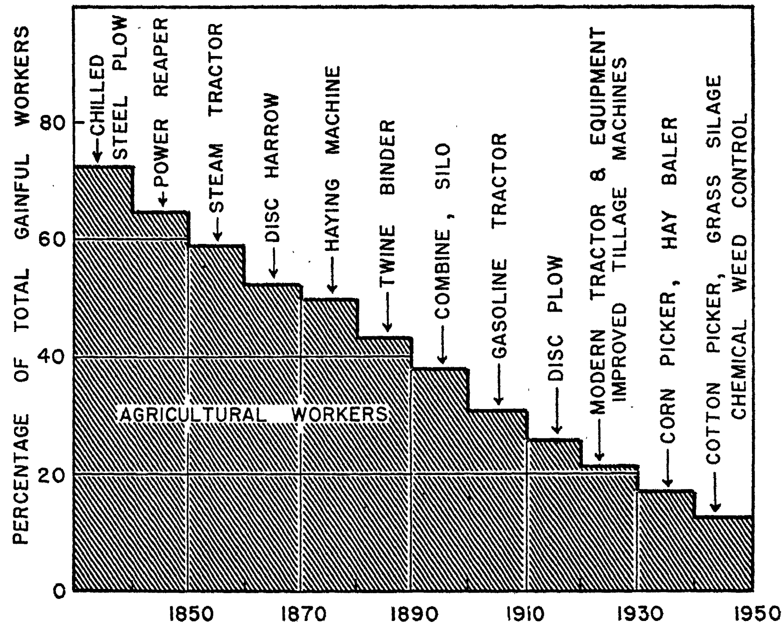
Who gets the meat? Is it the American artisan who is earning \$15 to \$20 or more a day; the British artisan who is earning \$6 to \$8 a day; the Italian artisan who is earning \$3 to \$5, or the Pakistani who is in luck to get \$1 a day?

Some persons say that the world food situation is nothing to worry about. They comfort themselves by saying that it is merely a question of inadequate distribution of the produce of the world's crop lands. We can produce more than we do. These self-comforters forget that food cannot be distributed unless it is bought and sold or given away. Much food was given away during and after World War II. Some is still being given away, chiefly by the United States, but this cannot continue indefinitely.

***September,* sowing wheat: proud of his ability to do it evenly.**

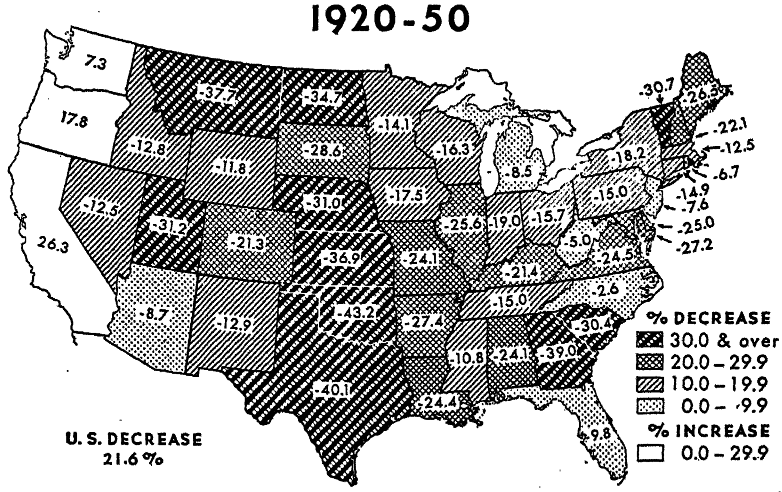
[5] William Blain, *The New York Times,* August 3, 1954, p. 20.

[6] See U. S. Department of Agriculture report, "Control of Production by Governments, a Selected Bibliography."



Much history: The modern economic era stands on a base of farm machinery. As farm workers in U. S. declined from 72% to 12% of workers, people were released for factory and other work. Note it is percentages. *U. S. Bureau of the Census*

CHANGE IN FARM POPULATION 1920-50



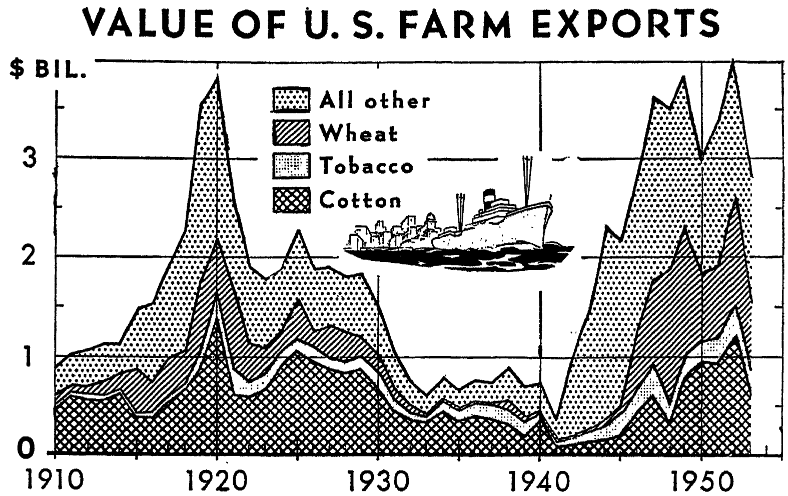
This shows actual decrease in percent, while total population increased from 105 to 150 millions. *U. S. Department of Agriculture*

In the long view it must be true that when other nations cannot get money or sell us their goods to pay for the meat we have to sell, our meat stays home. Therefore we have practically stopped exporting meat, and it has been a great surprise to us to realize that the United States with all its land has become a net meat importer, while Denmark has become a net meat exporter, sending to us 15 million pounds of ham in a recent year.

11. WILL OUR WHEAT EXPORT DISAPPEAR?

It is quite possible that after a few more generations the United States may also stop exporting wheat. Nearly all of today's export wheat comes from the new lands of United States, Canada, Argentina, and Australia. Population there, still scanty, is increasing, and grows wheat by following what the Germans call *raubwirtschaft,* "robber economy," rob-

Farming is our most precarious business. It must encounter drought and frost, bugs, rusts and blights, and foreign markets, plus wars and usual business conditions, and *produce for future markets.* This graph shows why the momentous decisions of the 1930's and 1950's to control farm production and price. The mountainous curves are made of quantity, high-price shipments for military and civilian relief. *U. S. Department of Agriculture.*



bing the plains of fertility collected through past centuries. None of these main wheat export areas is operating on a fertility-maintenance basis as is the practice in West Europe.

One of the most significant things about international trade in agricultural produce is first the disappearance of our exports of meat. Next is the disappearance of wheat exporters. Since 1912–13, India, Russia, Rumania, Chile, and others have left the export column. "And" said an expert in this field, "the export of Indian wheat was at the expense of India's own food supply."

We grant his conclusion and wish to discuss its cause and significance as illustrated by the situation in Egypt.

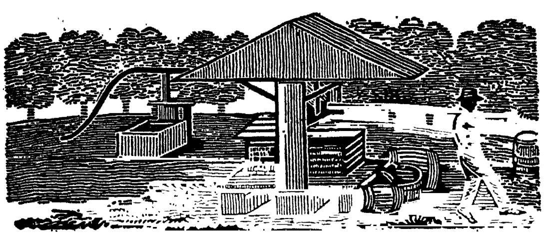
12. EXPORT BY AN AGRICULTURAL COUNTRY THAT LACKS MANUFACTURES

Egypt shows how the Age of Machinery introduces a new element into the function of agriculture in world trade. For 6000 years Egypt has supported its millions and its rulers with but little foreign trade. The Nile Valley produced almost everything the people needed, thanks to the annual inundation that washed the land, irrigated it, and fertilized it.

The new Machine Age brings new wants to the sons of the pyramid builders. Their imports prove that they think they need locomotives, steel rails, coal, oil, autos, telephones, radios, typewriters, chemicals, and an endless list of gadgets and manufactures. These products of metal, science, and advanced industry and other climates must be *imported.* They must be paid for, and something must be sold to get the money. In this respect Egypt is like any American country district and many of the 60-odd sovereign nations.

What can Egypt (or Uruguay or Montana) sell to get credit with which to buy these results of advanced industrial culture? These agricultural areas, like any other area, must sell manufactures, minerals, crops, and services—or go without. Egypt happens to be woefully short of manufactures and exportable minerals, and service income (travel) is small.

Egypt has the rich agricultural resources of the Nile irrigation. It exports salt, has a supply and small export of rock phosphate, a partial supply of petroleum. There are no other resources worth mentioning, not even pastures or forests. The population is now more than 3.5 persons per cultivated acre. Most people



October, **pressing cider for a home-made drink.**

November, **breaking flax to spin for linen bed sheets. Two cows.**

are tenant farmers, working tiny patches of land with almost unbelievable care and paying exorbitant rent.

The figures of Egyptian foreign trade are astounding in quantity and composition. The shops and stores of Cairo sell almost everything that is produced in the factories of Europe and the United States. For 1951, the latest year reported by the Department of Commerce, the figures of Egyptian exports in round numbers were:

	$ Million
Total	569
Leading items	
Cotton (raw)	471
Cotton yarn	20
Rice	41
Onions, molasses, cotton-seed oil	9
Salt, phosphate, and ore	7
Miscellaneous	21

In that same year, Egypt imported:

	$ Million
Total	676
Leading items	
Wheat, corn, and flour	110
Tea, coffee, fruit, and other foods	50
Textiles and clothing	52
Motor vehicles, machinery, and electric equipment	104
Iron, steel	37
Fertilizers	35
Petroleum products	37
Wood	36
Paper and book-sellers' materials	59
Other manufactures	27

To feed themselves and support this vast import, Egypt's crops occupied:

	Thousands of acres
Total	8064
Corn, wheat, millet, barley, and rice	4304
Legumes and onions	355
Cotton	2055

The grain area was only 2.1 times the cotton area. In the United States that year our grain area was 7½ times our cotton area. But note what the Egyptians bought with cotton money —almost the sole basis of foreign payments.

The plight of the truly agricultural country. The conclusion seems plain. Such a country must export agricultural produce or do without imports. Egypt's agricultural exports produce hunger and malnutrition for millions of her people.

The Agricultural Attaché at the U. S. embassy in Cairo reports (1953):

> The [Egyptian] Ministry of Agriculture studies show a decline of 24% in the per-capita daily caloric intake of Egypt since 1929–30, with proteins declining 29% and fats 4.5%. This same Ministry cited "the high mortality of preschool children and the slow rate of growth exhibited by those who survive" as indicating that the nutrition of children of low-income families was "far from satisfactory."

If the proportion of agricultural workers is very high in any country, it almost surely means poverty. They are not using machines. Production per man must be low. The United

December. **Fire in Franklin (Ben) stove. Mother nurses child; little sister reads; elder daughter spins. One of the authors values as heirloom, a blanket made about this time by an ancestress in adjoining Frederick County, Md.**

States has had 11.6% of its workers on farms. Egypt has about 62%, and national prosperity hangs on the price of cotton.

Compare Egypt and Denmark. It appears that Egypt might be better off if a few million farmers became factory operatives and reduced the dependence on money derived from cotton. Can Egypt do this? In competition with the Western World? With Japan, India, and China? Denmark has done something very much like it on a basis of sand, climate, and Danes, but Egypt is generations behind Denmark—and the Danes. Can she ever catch up? Her one modern manufactured export is yarn, but it pays for but a fraction of the finer textile imports.

Egypt a type. Egypt has been considered here at some length because in many ways it is a type. It is a somewhat extreme case of what some now call "underdeveloped" countries. The forces controlling Egyptian trade apply more or less to all countries outside of Soviet Russia, northwestern Europe, the United States, and Canada. In 1950 China exported food to Russia for machines. Chinese starved.

Hostages to fate. It was said of old: "The man who hath wife and children has given hostages to fortune." In national terms, today we paraphrase: "The nation that cannot grow its own bread and butter, meat, milk, potatoes, and some fruit has given hostages to fate." Other nations also have given hostages to fate. This is true of a nation that has nothing but agriculture. It must export heavily of farm produce to get factory stuff or remain in the domestic economy of Caesar, George Washington, and Tibet. We have cited the case of Egypt.

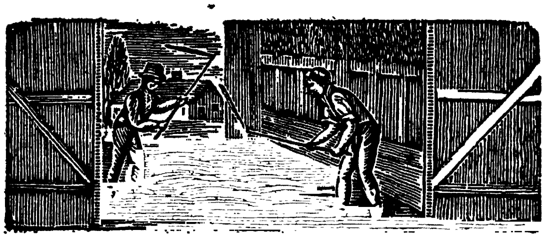
Some countries have a temporary way out through mineral export, which renders the same service for them that cotton does for Egypt. Minerals to the fore, for a while. If a nation has exportable minerals and negligible manufactures, it may, while they last, export them and buy what it needs. Witness Chilean nitrate, Mexican silver, Rhodesian copper, and British coal. Saudi Arabia is the most plushy, riotous, and astronomical example of this. Here were some desert oases where Arabs worked for 10¢ a day and exported some dates and a few goat skins. White men came along, struck oil—the richest oil. Suddenly there is an industry and good jobs for the Arab workmen. The absolute sovereign pockets $50 million a year as his 50-50 share of profits—while oil lasts. The plight of Arabia when oil is gone — ?

13. UPS AND DOWNS FOR THE COUNTRY WITH ONE OR TWO RAW EXPORTS

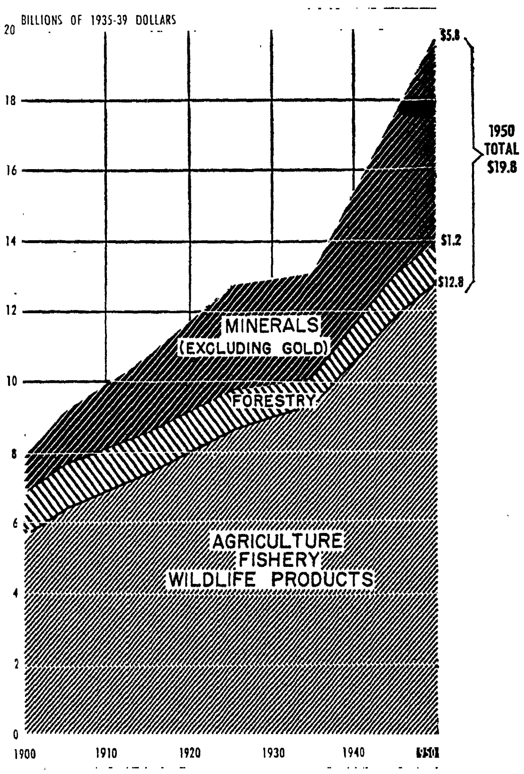
These countries that depend on one or two products for export money are the footballs of prosperity and depression. Take Australia as an example. She was heavily in debt to Britain for bonds at fixed cash interest. To get interest money *and* imports, Australia exported wool, mutton, and wheat. In the depression of the 1930's the prices went down a half. Think what that would mean for any industry you know something about.

This Australian situation brings to mind the famous case of Shylock and his celebrated bond. England got the wheat and wool—lots of them—cheap; Australia paid her interest and had almost nothing left with which to pay for British manufactures. We must manufacture or do without, said they, and slapped on tariffs to keep out foreign manufactures. England got her interest money but lost a market. The biggest steel plant in the British realm, so reported, rose in Australia.

Little fellows like Uruguay or poor ones like Iran or Turkey or Central America had to take the low prices for their raw material, go half-hungry, and patch their old clothes.



***January,* threshing wheat with flails beside barn door to let dust escape.**



The bases of economic life show that the Machine Age really stands on the farm and runs on minerals. Note percentages of change. Based on constant dollars 1935–39 value. *President's Materials Policy Commission, Resources for Freedom, Vol. I, p. 5*

14. THE OVERDEVELOPED COUNTRY

The United Kingdom is another type of country—the mature, *overdeveloped,* West European type, the type that has given hostages. The United Kingdom led the world in coal, steel, the first factories, the first big merchant fleet. She imported raw materials, manufactured, exported, bought food. Her population increased to the point where more than half the food was imported and paid for by exports of coal and manufactures. Britain's nicely balanced world was knocked to pieces by two World Wars which ate up her billions of foreign investment and hastened the growth of manufactures in many rival countries.

Her great export of coal has declined because of oil, high cost of deep mines, and other factors. British publicists now say, "We must export or die." We would change it to: they must export or accept a terribly reduced (almost vegetarian) standard of consumption, or reduce the number of people on the islands. Britain is in a tight spot since, despite our surpluses, the supplies of food for import are diminishing and industrial rivals in many lands are cutting into Britain's markets, and therefore into her ability to buy.

The case of Britain is a type, the Western European type that cannot keep its present standard of consumption without selling something and buying food. You will note later that some of these European countries with fairly well-developed manufactures are following Egypt's example a bit by exporting agricultural produce, but they are also making manufactures and exporting some. This threatens to lead them into Britain's position by increasing their population while importable food declines.

February. **Skating. The year's supply of fuel. The only horse that appears.**

5· Wheat—The World's Prime Breadstuff

To most of us the word "grass" brings to mind something that we walk on and cattle eat. But we must also remember that the grass family is one of the largest known to botany and forms the primary basis for the world's agriculture. Among the grasses, cereals are the most important to man. These plants pack starch, gluten, oils, and other elements of nutrition into their seeds to provide for nourishment of their young before their roots get well into the earth. This food is equally acceptable to man and to many beasts.

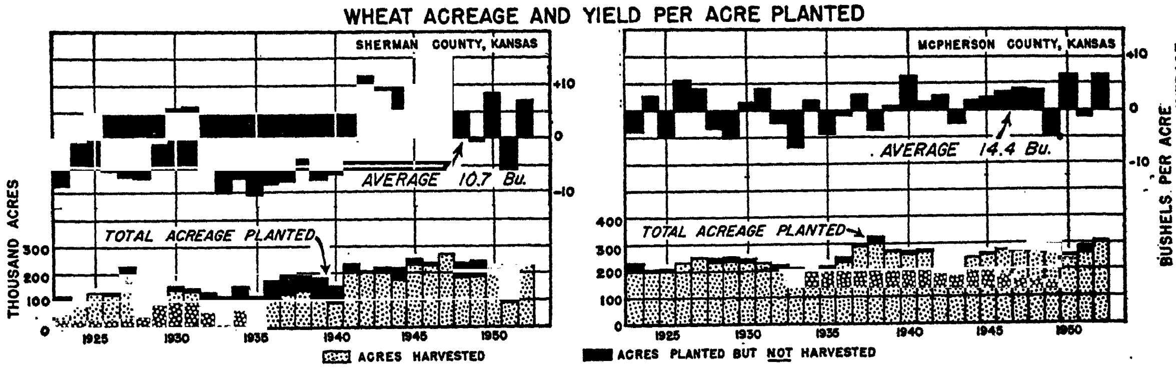
Among the cereals, three "master" grains, each with a world production of over 5 billion bushels, are fundamental to agriculture in the world's most productive regions. Corn, native to the Western Hemisphere, is an important food crop in many areas and vital to our meat supply. Wheat has spread widely from its supposed place of origin near the eastern Mediterranean and is the world's leading bread grain. Rice, indigenous to southern Asia, remains the basic food for hundreds of millions.[1] The secondary grains supplement the "big three" in their major areas of production and extend productive cultivation into less-favorable environments—rye, oats, and barley in the cooler climates of higher latitudes and altitudes; then sorghum, millet, and again barley on the hot, dry margins.

1. THE WHEAT PLANT AND ITS CLIMATIC REQUIREMENTS

Wheat is the most widely grown of the major cereals. It is found near latitude 60° in the Northern Hemisphere and latitude 40° in the Southern. Within these limits the world wheat map (Fig. 88) reveals that the major areas of concentration lie within two broad latitude belts, between 30° and 55° N. and 30° and 40° S.

The importance of moisture and temperature. During the first period of its growth the wheat plant consists of a tuft of green blades much like any other grass. Later it sends up stalks of straw that support the grain-bearing heads. The number of stalks and heads depends on the size and vigor of the plant, and these are greatly dependent upon the duration of cool, moist weather. If the cool, moist season of formative growth is long, the grasslike development is good and the heads many. Early sunshine that shortens the damp period shortens the grain yield. The formative period is therefore important. In milder climates it usually includes the winter; where the winters are too severe it falls wholly in the spring and summer. Winter wheat, therefore, the wheat of warmer latitudes, is sown in autumn and harvested early the next summer. Spring wheat, the wheat of the lands of cold

[1]See Raymond J. Pool, *Marching with the Grasses*, University of Nebraska Press, 1948, pp. 29 ff.



Lower the average of rain, and of wheat yield, and the variability of both increases.

Sherman County, northwestern Kansas, on the high plains, 18″ rain: skyline clean cut, houses as shadeless as desert stones. Note relationship between below-average yields and amount of abandonment. Acre yield, 10.7 bu. av.: one-crop wheat farming.

McPherson county, central Kansas, 150 miles SE of Sherman, rain 28″: agriculture somewhat diversified, trees dot landscape. Note fluctuations down and yield up.

winter, is sown in spring and harvested at the end of summer.

Although wheat grows in many and widely scattered lands and different climates, for the period of its early growth it must have moderate rainfall[2] with rather cool, moist weather, long continued if possible. This must then be followed by warm, bright, and preferably dry weather. Abundance of summer rain is fatal to extensive wheat growth. It causes the plant to make straw rather than grain, and also induces rust and other fungus diseases to attack the plant. If excessive, it causes the grain to shrivel before harvest, and often causes it to mold or decay after harvest. O. E. Baker has pointed out that little wheat is grown in the Cotton Belt of the United States, where temperatures of the two months before harvest average over 68° and annual rainfall exceeds 50 inches.[3] Even the eastern Corn Belt has sufficient moisture at times to injure the wheat crop to some extent, although wheat is grown in every county and almost every township in the whole region.

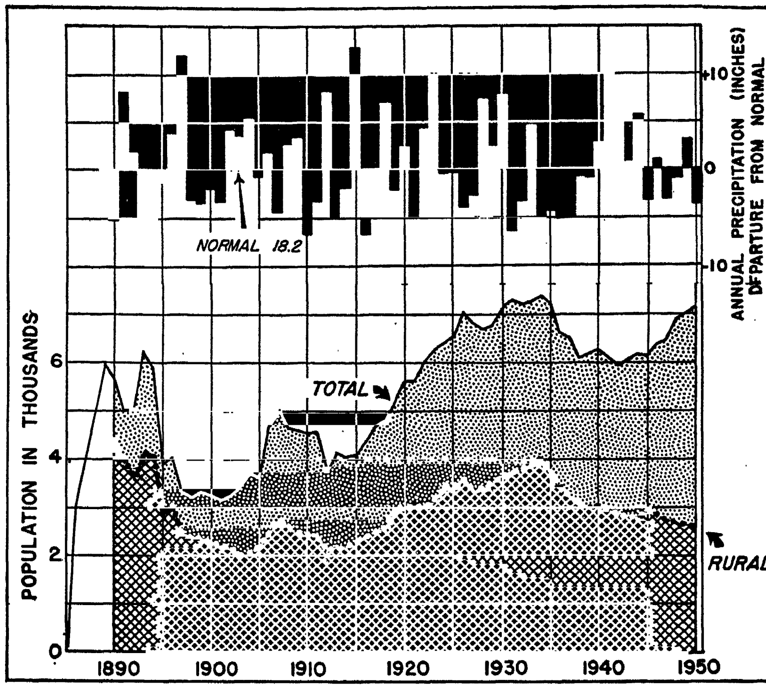
This combination of heat and moisture sets the northern limit for wheat in Argentina and limits its eastward expansion in India and its penetration into south China.[4] The whole tropical zone, with its tendency toward summer rain, is therefore practically barred from wheat growing, except here and there where some climatic exception holds sway—as in Egypt, arid, but having enough river water for irrigation, or as in Mexico, Colombia, and Ethiopia, where high elevation gives the temperate conditions to plateaus and mountain regions. The most important of these tropic exceptions is the Indian peninsula, where the summer rains, brought by the monsoon, arrive after the wheat has been ripened by the heat and droughts of early summer, thus providing one of the world's important wheat areas.

Ill effects of an open winter. In addition to the handicap of summer rain, parts of the Corn Belt of the United States have another difficulty in the alternate freezing and thawing of the early spring and late winter. This is much worse than a heavy mantle of snow or even solid and continuous freezing. The expansion and resultant lifting of the top soil by freezing, and the contraction of the thaw, gradually pull the wheat plant out of the ground.

[2] The moisture left in the soil from a period of seasonal rainfall is sufficient in some parts of the Pacific slope to mature a crop of wheat upon which no rain falls.

[3] O. E. Baker, "The Potential Supply of Wheat," *Economic Geography*, January 1925, pp. 26–27.

[4] See K. W. H. Klages, *Ecological Crop Geography*, Macmillan Co., New York, 1942, pp. 343–347.



Rainfall and population in Sherman County, Kansas. Four declines in population with shift to town. Note that rural population continued to decrease through the wet and prosperous 1940's, a period of rapid mechanization, increase in farm size, and abandonment of many rural farmsteads. The "sidewalk" farmer, living in the local towns, and the "suitcase" farmer, operating from a greater distance, are elements in this rapid change. See Kollmorgen and Jenks, full refernce, footnote 15, p. 83.

This is one reason why wheat is much less important in many Corn Belt localities than it was 60 or 70 years ago.[5] The wheat regions have been shifted beyond the Mississippi valley southwestward, into a less frosty climate for winter wheat, and for spring wheat into the northern Great Plains, the Red River Valley of the North, and the plains of Canada, where the rigors of the winter climate have no direct effect upon the wheat because it is spring-sown. Between these two wheat areas is an interesting gap where it is too hot for spring wheat and too cold for winter wheat—the land of oats. Wheat production has moved about surprisingly.

2. REGIONS WITH GOOD WHEAT CLIMATE

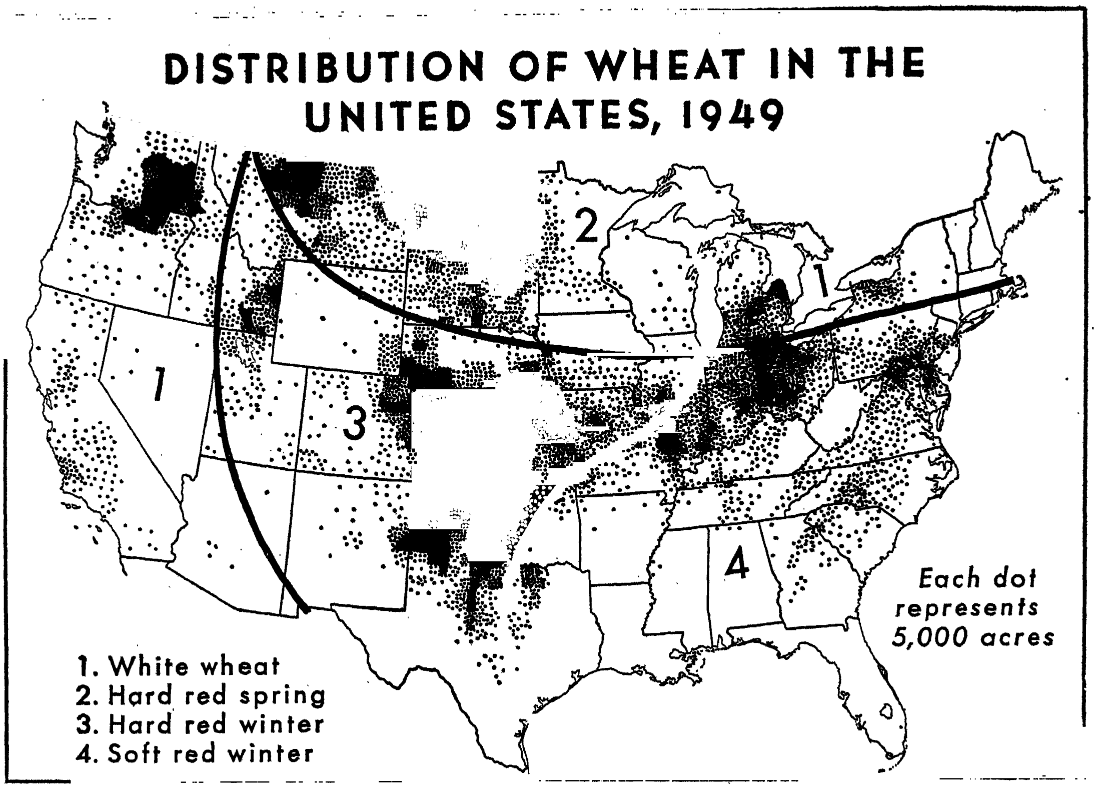
Although wheat is grown in many climate regions, most of the important areas of wheat production have an annual precipitation of less than 30 inches. Some wheat is even grown in areas receiving as little as 10 inches per year. Therefore, wheat is the crop of the subhumid and semiarid climate regions—transitional zones between humid areas and the deserts.

The widespread Mediterranean type. The Mediterranean climate with its mild, rainy winter and hot, dry summer is highly favorable for wheat.[6] Regions with this Mediterranean wheat climate are found in all continents in a climatic zone with western ocean frontage corresponding to the Mediterranean basin in latitude and produced by the same elements of the world wind system. They lie upon the margins of the desert regions that afflict each of the six continents in the latitude of transition between the zones of the trade winds and the prevailing westerlies. Comparison of the world wheat map (Fig. 88) with the climate map in the front of the book shows that wheat is grown in all regions of this climate type, especially the Mediterranean basin itself and southern Australia, but also in South Africa, central Chile, and California.

The grasslands of the continental interiors. The Mediterranean regions are small in

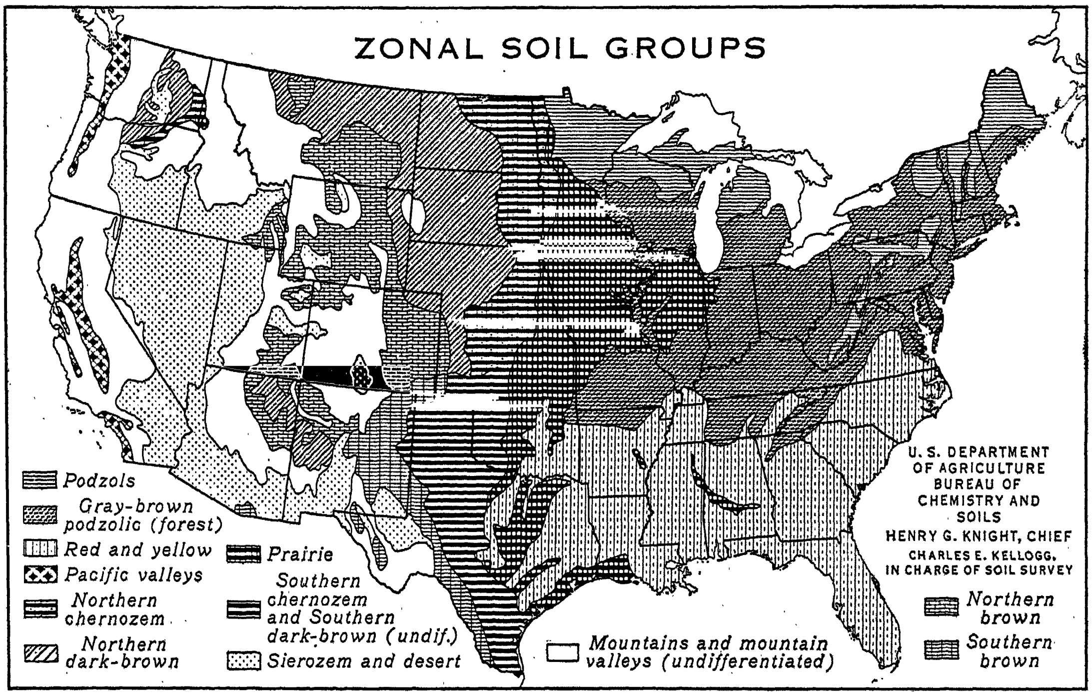
[5] Iowa, which averaged about 30 million bushels annually from 1870 to 1880, is now producing about 5 million bushels each year.

[6] However, wheat yields in Mediterranean regions are below those for many other areas because of the sharp decrease in rainfall during the early spring period of rapid wheat growth. M. K. Bennett, "Climate and Agriculture in California," *Economic Geography*, April 1939, p. 157.



Above. Region 2 is spring wheat; others, winter. Note how spring and winter separate on Great Plains. Compare the value of the dot with other dot maps.

Below. The really rich soils are the grassland soils, prairie, chernozem (black), and the brown and dark brown. The cities of Europe and America have been fed this last half-century by grain (and meat) from the grasslands and powered by the coal mines and oil wells. The processes of *raubwirtschaft* promise to be modified in the next half-century. *U. S. Department of Agriculture*



area and include much hilly terrain. Consequently, it is the flat, fertile grasslands of the continental interiors that have provided the basis for the doubling of the world's wheat acreage in the past half-century. These grasslands include several climate types, but like the Mediterranean regions, they lie between humid and desert zones.

These relationships are well illustrated by the distribution of wheat regions in North America. The western part of our country, about 40% to 45% of the whole, is mostly too arid for cultivation except when irrigated. The district of greatest aridity is in the desert southwest and the higher but not-quite-so-arid Great Basin. As we go north and northwest from the dry Great Basin into an area of increased rainfall, we find the wheat areas of eastern Oregon and Washington. Going from the east toward the arid region we find close to the 20-inch rainfall line two of the most important wheat belts in the world. The Winter Wheat Belt in western Texas, Oklahoma, Kansas, and Nebraska and in eastern Colorado occupies the western portion of the Corn and Winter Wheat climate region and extends well into the regions of Temperate Grassland climates.

To the north the Spring Wheat climate region occupies a similar position between humid and arid areas. This third wheat belt[7] is found in the Dakotas and Montana and extends into the plains of western Canada. Here the winter is too cold for fall-sown (winter) wheat, but a fortunate rainfall distribution permits the planting of wheat in spring. The rather light rainfall of 15 to 20 inches has a maximum in early summer or midsummer, which promotes the grassy growth of wheat. A *hot* June injures this wheat and sets the southern limit of the region. The wheat usually ripens well in the drier late summer. The plains in the center of North America form one of the most important granaries of the twentieth century. But this importance is due more to great area and to the impracticability of raising other important cash crops than to any perfection of climate.

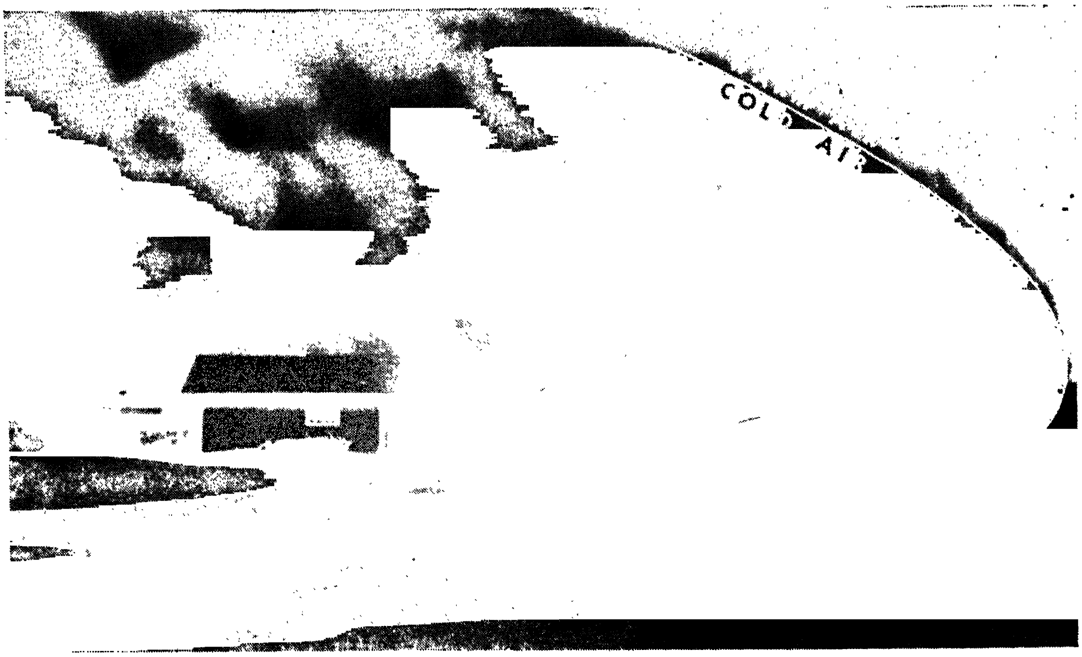
There is much marginal land with a small margin of safety arising from the painful frequence of drought, hot Junes (for spring wheat), hot autumns (for winter wheat), frost, hail, and pests of grasshoppers and sometimes rust and scab. Further uncertainties of income arise from fluctuating price, depending on production of competing regions in every continent. These areas, however, have fertile soils, the black (chernozem) and dark brown soils of the continental interiors.[8]

Comparison of the world maps will reveal similar coincidences of climatic regions, major soil groups, and wheat production in the humid-arid transitional zones stretching from southeast Europe through European Russia into central Siberia, in North China and Man-

---

[7] Note how these three areas show up on the two maps of the United States showing the distribution of wheat on pages 76 and 85 and the types of farming, page 136.

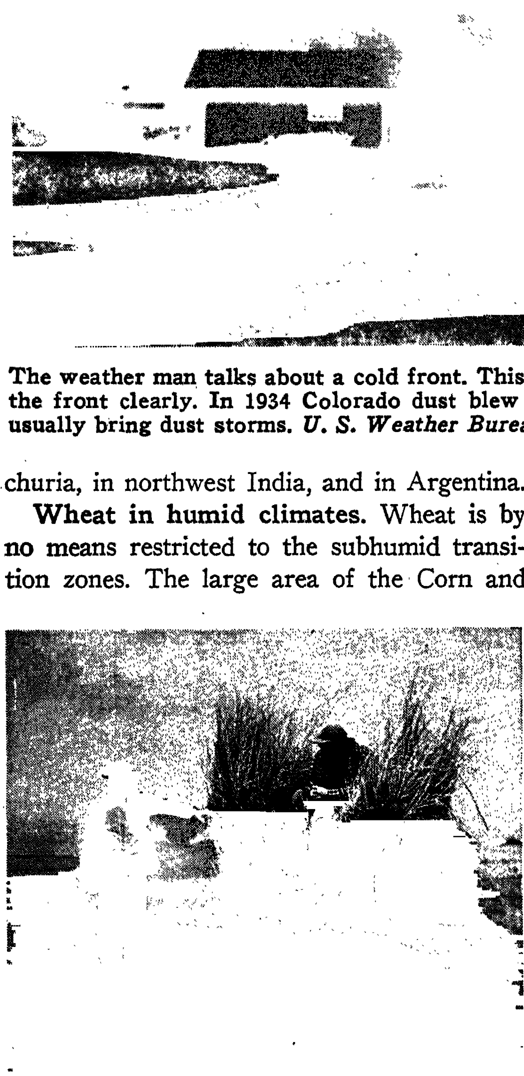
[8] "After a long period of floundering with unclassified soil facts it has recently been discovered by Russian students that the development of earth or rock material into soil goes through a cycle—young, mature, old. The startling fact is that climate dominates the character of the *mature* soil almost without regard to its geologic origin. . . . The black prairie soils of the middle western regions of the United States furnish an illustration of the theory of climatic causation of soils. Between the wet forest of eastern Texas and the subhumid and treeless northwestern Texas, and also between the humid forests of Indiana and the semi-arid sagebrush lands of western Nebraska, there is a transition in rainfall and in natural vegetation. Between each of these two regions of rainfall contrasts and their resulting vegetation contrasts is a wide belt of grassland. Grassland makes black soil—black waxy, as it is called in Texas. Of similar origin are the black wheat lands of central Kansas, eastern Nebraska, eastern Dakota, Manitoba, Saskatchewan and Alberta. These black soils are a transition belt between the eastern and northern forest (humid) and the sagebrush plains (dry). Similar zones of transition in rainfall, in vegetation and in soil are found in the black land grain fields of other continents. The limited black land area in Argentina has made that country a grain exporter. In Eurasia the Black Belt sweeps from the Black Sea through Russia and far into Siberia. Australia has a little strip, as has the Sudan. This black soil is the prime grain land of the world." J. Russell Smith, "Agriculture: General Problems," *Encyclopaedia of the Social Sciences,* The Macmillan Co., New York, Vol. 1, 1930, pp. 593–594. See Louis A. Wolfanger, *The Major Soil Divisions of the United States: A Pedologic-Geographic Survey,* John Wiley & Sons, New York, 1930.



The weather man talks about a cold front. This is a picture of it, loaded with dust that lets us see the front clearly. In 1934 Colorado dust blew to the Atlantic Ocean. Droughts on Great Plains usually bring dust storms. *U. S. Weather Bureau*

churia, in northwest India, and in Argentina.

Wheat in humid climates. Wheat is by no means restricted to the subhumid transition zones. The large area of the Corn and Winter Wheat climate in the United States emphasizes the importance of this crop in more humid environments. Northwest Europe, with its moist climates, is also an important wheat producer, as are the Cotton, Rice, and Corn climate regions in central China and Japan. In all these densely populated areas, winter wheat is an important crop in an intensive, diversified agricultural system and yields are much higher and more dependable than in the Mediterranean or continental grassland zones.



A bunch of blue stem grass with its hundreds of miles of roots held the top of this High Plains knoll while 5 feet of soil blew away—Texas to Alberta. With cycles of wet and dry and blow away, how long will the wheat region last with such free enterprise? The farmer thinks it's *his* land to butcher, but it's *your* basis of food. *U. S. Soil Conservation Service*

3. TECHNOLOGY, SCIENCE, AND WHEAT

Man has used wheat since before the dawn of history, but modern wheat production is the result of the industrial and scientific revolutions of the past two centuries. To fill the stomachs of the bread-eaters in the growing industrial cities of Europe and North America, efficient ocean transport had to be developed and railways were pushed into the grasslands of the continental interiors. The expansion of wheat production in these areas has required revolutionary developments in plant breeding, machinery, and agricultural techniques.

The introduction of new wheats. The introduction of wheat varieties from other parts of the world contributed greatly to the expansion of our wheat belts during the closing years of the nineteenth century.

For example, Turkey wheat was the first hard red winter wheat introduced into what is now our major winter wheat area. Menonites from southern Russia brought seeds of this wheat to central Kansas in 1873, and found it well adapted to the area. "The wheat attracted only local attention, however, until Carlton, one of the pioneers in plant improvement, discovered it and recognized its resistance to drought and good yields under adverse conditions."[9] In 1900 Carlton went to Russia and brought back additional seeds of Turkey wheat as well as several other varieties. By 1919 Turkey occupied 99% of the acreage planted in hard red winter wheat, and it remained the leading variety of all wheats in the United States until 1939.

A comparable development occurred in the American portion of the Spring Wheat Belt. In 1860 Red Fife, a hard red spring wheat, was introduced from Poland via Germany, Scotland, and Canada. For decades it was the leading variety of spring wheat and a parent for subsequent hybrids which have surpassed it. Other "immigrant" wheats include varieties of durum from southern Russia into Minnesota and the Dakotas, and Australian wheats into the Pacific Coast states.

This introduction of new varieties has given new materials for the plant breeders to use. Plant explorers have scoured the far corners of the earth in search of plants adapted to particular environments and uses, and all branches of the wheat industry have benefited greatly from plant importation. The U. S. Department of Agriculture has obtained over 8000 foreign introductions of wheat from more than 50 countries and has viable seed of nearly 5000 of these.

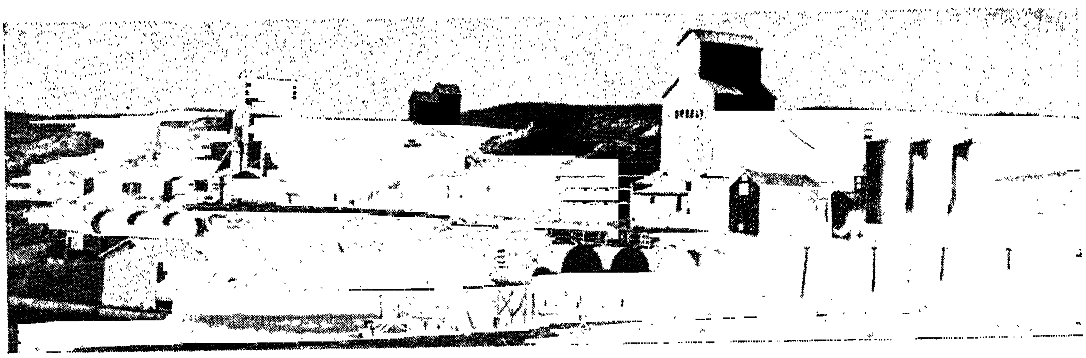
Plant introduction as a method of wheat improvement reached its peak in the closing years of the nineteenth century, and since then our cerealists have achieved greatest progress through pure-line selection and hybridization. Since we have come into the possession of Mendel's Law, the usable working law of heredity,[10] we are able to change wheat and most other crops grown by man.

Examples of breeding new wheats. An occurrence in the northwest is illustrative of the new-found ability that is destined to enrich every land in the world. On the lava plains of the eastern part of Washington, the practically rainless summer permits the farmers to let the wheat stand for a month after it is ripe. The harvesting can accordingly be extended over a period of several weeks, and comparatively few hands can thus take care of vast farms. It so happened, however, that the best-yielding variety permitted many of the grains to scatter out of each head and fall to the ground before the wheat was cut. The rival variety that held its grains tightly was so tender as to be injured one year in three by the frosts, which follow periods of warmth and growth, in this land of open winter where wheat is usually sown in the fall. An experimenter at the agricultural experiment station in the state of Washington crossed these two varieties, and produced a third variety which has the frost-resisting qualities of one and the grain-holding qualities of the other, thus permitting large extension of wheat growing on the wide fertile lava plain of the Columbia basin, which now averages about 24 bushels per acre, while the average of the whole United States is but 16 per acre.

Our Spring Wheat Belt provides another example of plant breeding. This time a se-

[9] USDA, *Yearbook of Agriculture, 1936,* p. 216. This volume (pp. 207–238) contains much information on the introduction and breeding of wheats. Other USDA sources used in the preparation of this section are: *Yearbook of Agriculture, 1943–47,* pp. 379–384 (for developments after 1936), and *Distribution of the Varieties and Classes of Wheat in the United States in 1949,* Circular No. 861, March 1951. Comparison of maps in this circular with those in the *1936 Yearbook* reveals striking changes in the areas occupied by the different varieties.

[10] Donald F. Jones, *Genetics in Plant and Animal Improvement,* John Wiley & Sons, New York. 1925.



Fort Benton, Montana, population 1640. Here grain elevators and oil tanks stand for body and blood of economic life of the thin and scattered communities of the Great Open Spaces—Texas to the Great Northern Forest of Alberta. *Great Northern Railway*

quence of hybrid varieties was developed to meet a succession of problems. During World War I, Red Fife was displaced by Marquis, developed in Canada by crossing Red Fife with Hard Red Calcutta and introduced in this country in 1912. For 20 years the Marquis variety retained the universal approval of farmers, grain traders, and the milling and baking industries, because this early maturing and drought-resistant wheat escaped rust at first, gave high yields, and proved excellent for milling and bread making. Marquis, along with its offspring, Ceres, suffered greatly from the stem rust epidemics in 1935, 1937, and 1938. By 1939 both had been displaced by Thatcher. Thatcher, another offspring of Marquis, was the first hard red spring wheat that was highly resistant to stem rust. But it proved susceptible to leaf rust. However, plant breeders had anticipated this and developed several varieties (Rival being the most important) resistant to *both* stem and leaf rust, and these have replaced Thatcher in the infected areas. Finally, another variety, Mida, first distributed in 1944, became the leading spring wheat in the United States by 1949. Meanwhile, the mighty Marquis has fallen from about 16 million acres (87% of the hard red spring wheat acreage) in 1929 to less than 900,000 acres (5% of the total) in 1949, found mostly in the western part of the belt in Montana.

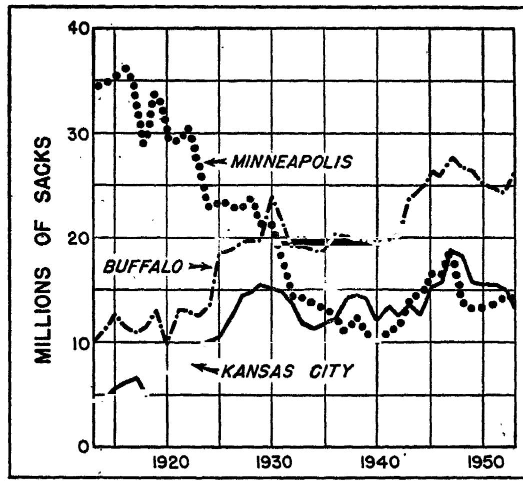
From these examples, it can be seen that breeding not only extends the potential areas of wheat production into less favorable environments, but also increases yields in the longer established areas. Wheat breeding (plant breeding) is in its infancy, and its methods are applicable to almost every plant that is now a crop and to hosts that are not yet cultivated.

Remember that sentence. It is vital to the understanding of the future. The Department of Agriculture reported 199 varieties of wheat growing commercially in the U. S. in 1949. This shows that the wheat breeders and the crop experimenters are still at work. It is likely that field competition will reduce the number of varieties to a few dozen.

Technology in flour milling. New types of machines have changed the growing of wheat and the making of flour. For many generations the technique of milling remained virtually unchanged. Wheat was ground into flour between pairs of circular millstones, the upper stone being turned by a vertical axle while the lower or "nether stone" remained stationary. When farmers began to grow wheat in Wisconsin, Minnesota, and the Dakotas, climate compelled them to grow hard spring wheat or none at all, but the wheat was so hard and so brittle that for many years it could not be satisfactorily ground. The bran broke up and mixed with the flour. It made a wholesome bread but not one pleasing to the eyes—and unfortunately for health we eat too largely with our eyes. Therefore, the new hard wheat made "poor" flour; it brought poor prices; and the lands upon which it was grown were in low esteem.

The importation of the roller or gradual-

reduction process from Europe in the 1870's solved the milling problem in this country and helped to bring about a great expansion of hard wheat production northward through Minnesota and the Dakotas into Canada and southward through Kansas and Oklahoma into Texas.[11] In this process wheat is crushed between revolving fluted iron rollers about 9 or 10 inches in diameter and 2 or 3 feet long, and it is gradually reduced into fine flour by repeated crushings. Approximately 70% of the wheat is converted into various grades of flour, the remainder consisting of bran and other by-products. In the United States virtually all flour is now milled by the efficient gradual-reduction process. The health advocates seem to be effecting an increased use of whole wheat (100%) flour of late.



Flour milling. Why such changes in flour production? *The Northwestern Miller Almanack*

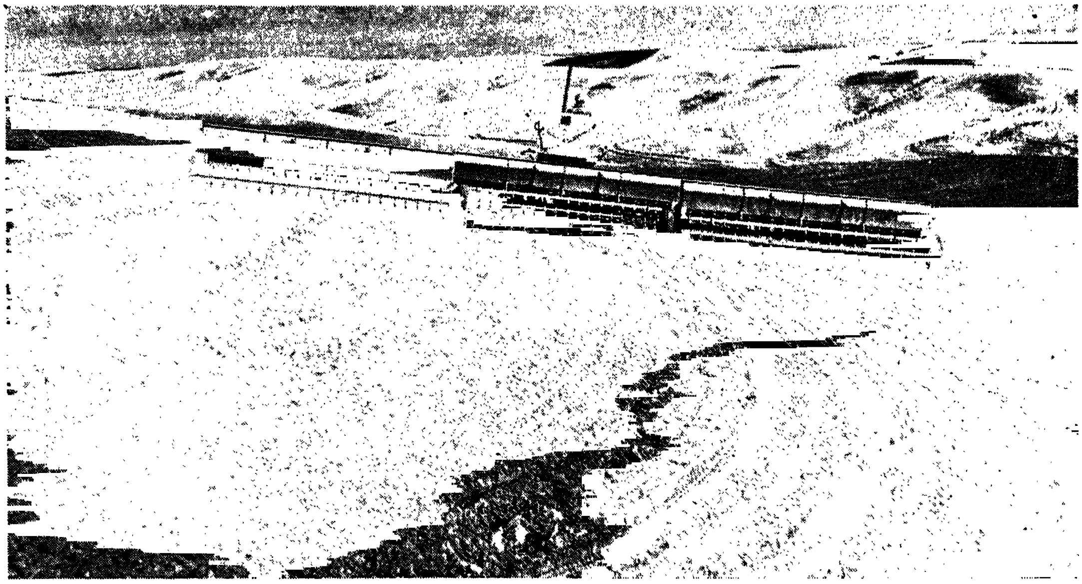
Machinery on the wheat farm. Expansion of wheat into the grassland areas has depended on improvements in farm machinery which have been evolutionary in development, and revolutionary in effect. Eighteenth-century wheat was cut in the Scriptural way—by a sickle held in one hand of the laborer while he grasped a few heads of wheat in the other. Then came the cradle invented in New England in 1806. It was a kind of scythe provided with fingers above the blade to catch and throw into an even row the straw it cut. The cradle was the main dependence of the United States through the first half of the nineteenth century.[12] In 1831 Cyrus McCormick of Virginia invented the first successful reaper, which cut and dropped the grain in bundles to be bound by hand. In 1878 John Appleby invented a twine binder that tied the bundles with twine; this replaced the unsatisfactory wire binders already in use and increased eightfold the speed in harvesting. The binder and the threshing machine, the latter often drawn and powered by a steam tractor, dominated the wheat harvest through World War I.

But already the combine, which cuts and threshes wheat in one operation, had made its appearance in California and the Columbia basin, where the grain dries out on the stalk in the hot dry summer. At first it was a huge, clumsy machine, drawn by steam tractor or 25 to 30 sweating horses, but has come into its own with the perfection of the internal-combustion tractor during the 1920's. Today most of our wheat is harvested by combines.[13] Self-propelled machines, operated by one man, may cut and thresh the wheat from 16-foot swaths and dump it into a truck alongside without pausing in their 3-mile-an-hour progress through the extensive fields of the wheat

[11] For a discussion of the development of the gradual-reduction process in France, Switzerland, and Hungary and its later adoption in the United States, see James C. Malin, *Winter Wheat in the Golden Belt of Kansas*, University of Kansas Press, Lawrence, Kans., 1944, pp. 188–197, and Evan B. Alderfer and Herman E. Michl, *Economics of American Industry*, McGraw-Hill Book Co., New York, 1950, pp. 508–516.

[12] The glamor of wheat harvest is gone from many an eastern American countryside. The reaper and combine have made commonplace an event that was talked about for months, prepared for for weeks, and which furnished the great athletic event of the year, where strong men sent each other to the shade in contests more grueling than the Marathon of the Olympiad. The man who could cut 5 acres of wheat per day with a cradle for 6 consecutive days was a MAN.

[13] Between 1920 and 1945 the proportion of wheat acreage harvested by combines increased from a modest 5% to 78%. See R. W. Hecht and Glenn T. Baxter, *Gains in Productivity of Farm Labor*, USDA, Technical Bulletin No. 1020, 1950, p. 77.



Seeding a 30-foot strip—any one of a dozen states—wheat, oats, barley, or rye. A similar hitch of disc harrows (or plows) rips up the soft black soil and makes it ready. After months of waiting, the combine (Fig. 64) comes to sweep the breadstuff into the truck—and away to New York, London, Rome, and Tokyo. ***John Deere***

belts. Gone are the thousands of migratory workers who followed the ripening wheat from Texas north into Canada, gathering the harvest and eating the tremendous meals prepared by the womenfolk. They have been replaced by a mechanized few who quickly combine the wheat and truck it to storage, then load their combines onto trucks or trailers, and roll on to the next farm, county, or state.[14] Combines have also made it possible for the individual farmer to harvest a larger acreage with less dependence upon seasonal labor but at a greater cost for capital investment.

Equally revolutionary improvements have characterized the development of cultivating implements. Here also the tractor has been vital, both because of its pulling power and because it can be operated for 24 hours a day if necessary during the relatively short periods of intense activity which characterize large-scale wheat operations. A recent study of the wheat area reports:

The 40's brought a real revolution in farming methods to the Wheat Belt. Not only were a variety of new field implements perfected by that time—duck foot, chisel, and rod weeder, for example—but good prices made it possible to buy these implements. The old mold board plow has almost disappeared and is used mainly to break out pastures. The one-way (heavy disc plow) has replaced it for working wheat fields. . . . [An] informant from western Kansas reports that he hitches three one-ways (covering a strip 45 feet wide) behind two hitched tractors . . . asked how much ground he turned in a day, his reply was, "I usually do a quarter (160 acres) and then knock off for the day, go to town, drink some beer, and go to a movie." Is this the climax of mechanical efficiency? It would be presumptuous to say so. In the summer of 1950, a wheat farmer in Sherman County with large acreages

[14] Typical of many such "outfits" is the one operated by N. R. Hamm of Perry in northeast Kansas. "Hammtown on Wheels" consists of 10 combines, 10 grain trucks, a repair truck, 3 house trailers, and a mobile kitchen. With a crew of around 27 men, operations usually begin late in May in Texas and are finished in mid-September in northern North Dakota. During the 1954 season "Hammtown" harvested 20,697 acres of wheat.

See also C. M. Williams, "Enterprise on the Prairies," *Harvard Business Review,* March 1953, pp. 97–102, for an informative discussion of the way in which the flexible American system of free enterprise adjusts to the vagaries of the wheat harvest.

had just purchased the most powerful caterpillar tractor available for about $18,000. He expected to work strips about 90 feet wide.[15]

The results of scientific and technical collaboration. These revolutionary improvements in wheat cultivation and harvesting cheapened its labor requirement from 133 minutes of human labor per bushel in 1830 to less than 10 minutes under favorable conditions at the present time.[16] This is an important factor contributing to the increased consumption of wheat by people traditionally using other grains in the Orient, Central Europe, and southeastern United States.

In these developments, the work of the scientist and the technician have been closely interrelated. The scientist breeds drought-resistant wheats. So the technician develops special equipment and tillage methods in order that the cultivation of fallow land will conserve the moisture from more than one year's rainfall to produce one crop of wheat. In the reverse situation, the technician develops the combine and the plant breeder works to provide varieties of wheat suited to combine harvesting: wheat with strong stalks, and with heads at an even distance from the ground, which will hold the grain without shattering until and after it is ripe and dry, ready for combining.

These various improvements in plants, machinery, and farming methods are not restricted to the United States. Large-scale, highly mechanized operations also characterize wheat production in Canada, Argentina, Australia, and the U. S. S. R. Nevertheless, much wheat is still produced in the good old-fashioned ways. Eighteenth-century hand methods prevail in most of eastern and southern Asia. In Europe, the nineteenth-century binder-thresher combination is much more common than the combine-tractor system of the 1950's. In 1953 the *Science News Letter* lamented the waste of human time resulting from the fact that a large part of the world's wheat was still cut with the sickle. In Lebanon we have seen wheat growing between rocks where only a hoe could plant and a sickle cut.

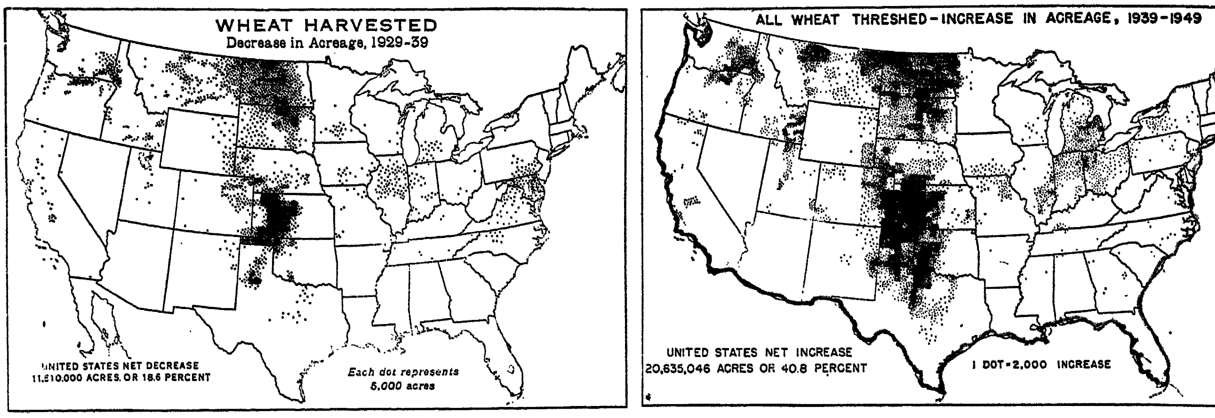
4. WHEAT IN SPARSELY POPULATED REGIONS

Yield and production of wheat in new countries. It is a peculiar fact that the world's greatest wheat exports are produced in regions of comparatively low yield per acre, and in regions that do not have the ideal wheat climate (see Fig. 91). This is because wheat, where it can be grown in treeless countries, is a good frontiersman's crop. With the aid of modern agricultural and transportation facilities, wheat is a money crop easily grown. A single farmer can in some cases raise 400 or 500 acres of wheat, but 100 acres is about the limit for corn because of the greater amount of cultivation required by this intertilled crop. No man can milk or care for more than a very limited number of dairy cows. In contrast, the wheat farmer has a fury of labor at planting, another at harvest, and 9 or 10 months for—perhaps a sojourn in California, Florida, or Europe.

The amount of wheat that he can grow is limited only by the amount he can harvest, and in the vast fields of sparsely populated regions this labor problem has been largely solved by the use of power-driven machinery. Furthermore, wheat has good keeping qualities, is easily shipped, is in universal demand. It is of more value in proportion to its bulk than hay or any other temperate-zone grain. It grows well in a greater number of places than either corn or oats. Once it is safely sheltered near a railroad, it can be marketed many months later, thousands of miles away. These advan-

[15] W. M. Kollmorgen and G. F. Jenks, "A Geographic Study of Population and Settlement Changes in Sherman County, Kansas," *Transactions of the Kansas Academy of Science,* December 1951, pp. 449–494; March 1952, pp. 1–37. Citation on p. 37.

[16] For the United States as a whole, the average labor requirement dropped from 1 man-hour per bushel in the years 1910–1914 to 20 minutes in the late 1940's. In the latter period averages ranged from 1 man-hour per bushel in the southeastern states to 15 minutes in the Pacific states. This illustrates the greater efficiency achieved in areas of large-scale, specialized wheat production. Calculated from Hecht and Baxter, *op. cit.,* pp. 11, 77.



Examine this pair carefully. One is a period of depression, drought, low yield, crop failures, low export, low prices. The other, exceptionally good seasons, yields, prices—war boom, industry boom. Note acreage changes. Farm-bloc action in Congress is explained. *U. S. Bureau of the Census*

tages of wheat as a money crop often make it the first and most profitable thing that can be grown by the new settler upon an open plain after the railroad is within reach, even though the average yield per acre be low. The distribution of the world's wheat crop is a fine illustration of the fact that products are often grown in places that are not best suited to them. Indeed, because of insufficient rainfall or an inadequate market for other crops, in many areas wheat is often the only important cash crop that can be grown, and serious problems result when the crop fails.

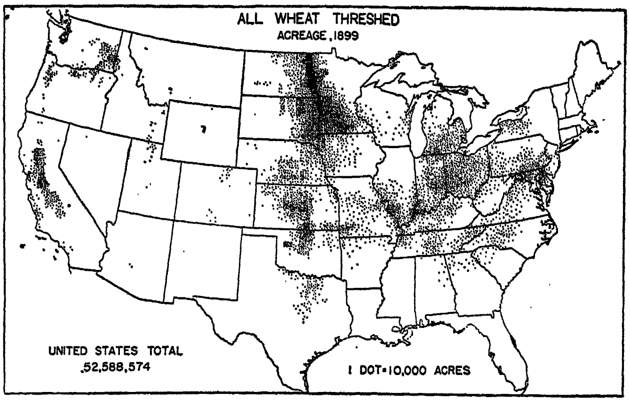
The world's chief wheat exports are grown upon such newly accessible plains in the Mississippi, Missouri, and Red River valleys of the United States, in western Canada, east central Argentina, southern Russia, the Danube basin, and southeastern Australia. Owing to the fact that there is no rival cultivated crop, the settler on a new plain, if not a tender of flocks, usually grows wheat year after year as long as the yield will be at all profitable, or until other crops become possible.

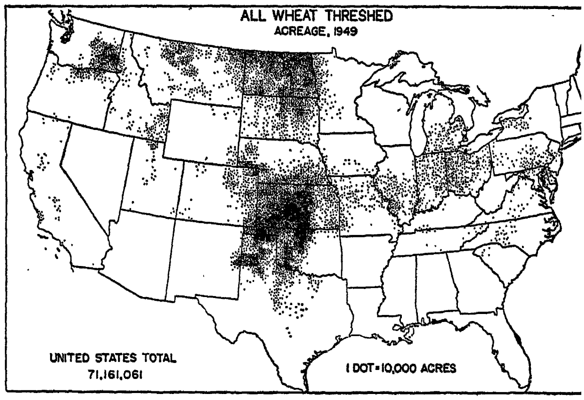
Even though wheatland soils are wonderfully fertile, continuous wheat-cropping has damaged the soil in many areas. This has even been the case on the miracle-rich lava soils of the Columbia Basin[17] and also on the flat, glacial lake-bed valley of the Red River in Minnesota and the eastern Dakotas. Declining fertility has helped cause the diversification of agriculture in many wheat areas. Grain farming still predominates in the Red River Valley but is supplemented by dairying, the raising of meat animals, and the production of such crops as potatoes and vegetables. This diversification and intensification is characteristic of the more humid sections of the wheat belts in other parts of the world.[18] In the United States it is indicated by the long-term decline in wheat acreage in many Corn Belt states as well as the extension of the Dairy and Corn Belt types of farming into areas where much wheat is grown. (Compare Figs. 76 top and 136.)

The problem of variability. In the wheat areas receiving less than 20 inches of precipitation, the possibilities of diversification are strictly limited by the low and variable rain-

[17] In this area specialization in wheat and continuous cultivation for more than 50 years reduced the organic matter in the soil by at least 35% and the nitrogen by 25%, with resultant reduction in moisture-holding capacity of the soil and increase in erosion. O. E. Baker, "Agricultural Regions of North America, Part XI, the Columbia Plateau Wheat Region," *Economic Geography,* April 1933, p. 188.

[18] For example, in the Prairie provinces of Canada, wheat provided 63% of the farm income in 1939 but only 44% of the larger income in 1944. Though partially the result of wartime conditions, this decline in the importance of wheat reflects efforts toward diversification in which declining soil fertility played a part. See C. W. Johnson, "Relative Decline of Wheat in the Prairie Provinces of Canada," *Economic Geography,* July 1948, pp. 209–216.





Fifty years have made big changes in our wheat map. In 1949 we had three major areas—Winter Wheat Belt, Spring Wheat Belt, and Columbia River Basin in eastern Washington and Oregon. Wheat is now important in the Corn Belt and the Middle Atlantic states, but less so than in 1899—compare Minnesota and Iowa on the two maps. California declines from its "bonanza" period. Especially striking is the westward expansion of wheat into the subhumid sections of the Great Plains states from North Dakota to Texas and into Colorado and Montana. But remember—the year 1899 was in the middle of a dry period while 1949 was one of a series of exceptionally good years for much of the Great Plains. *U. S. Bureau of the Census*

fall.[19] Without irrigation, production of intensive, high-yielding crops cannot be depended upon. In these areas, the wheat farmer is caught between variables: the variability of yield resulting from local climatic and other factors, and the variability of price as influenced by production in other wheat-surplus areas. Periods of high yields and prices bring optimism, money, and good years causing people in these areas to plow up more land for wheat.[20] But intervening periods of low yields, such as the "Dust Bowl" years of the mid 1930's, reverse these trends and cause much distress.[21]

Some diversification is possible by planting hardy grain crops, such as sorghum and millet. But the basic land-use problem for all these marginal areas will always be the proper balance between cultivated land and grass for range livestock. The possibility of much higher income per acre weighs this balance heavily in favor of wheat and provides many a headache for the conservationist, the government official, and the wheat farmer the world over. Recognition of the problems of variable farm income, especially as revealed during the 1930's, has led most of the governments in wheat-exporting countries to adopt various systems of wheat price support. Meanwhile importing countries protect their wheat growers by tariffs and other means. There remains, for years to come, the ever-present prospect of a wheat "surplus" in a hungry world.

The iron hand? Is a change coming? A revolution? Recall Section 9 of the preceding chapter, and you will see that economics, sociology, and politics have a hand, with geography, in making crop choices. Enter sociology, economics, and politics.

5. THE PRODUCTION OF WHEAT IN EUROPE

Importance of Europe. North America is such a heavy producer and exporter of wheat

[19] The annual average is a very crude measure in this connection. The actual effectiveness of precipitation for wheat is influenced by its variability and seasonal distribution; and by temperature, topography, and soil conditions. See Klages, *op. cit.*, pp. 343–347.

[20] A Canadian agricultural expert said to the senior author as they passed a magnificent field of wheat in Alberta, "That crop is good enough to keep that farmer broke for six years."

[21] Kollmorgen and Jenks, *op. cit.*, pp. 456–467, 20–29, provides much geographical-historical perspective for these fluctuations in the Great Plains wheat area. For an analysis of the problems of a wheat area caught in a period of low yields and low prices, see G. E. Britnell, *The Wheat Economy*, University of Toronto Press, Toronto, 1939.

that it is something of a surprise when we first learn that normal, peacetime Europe, excluding the Soviet Union, produces much more wheat to the acre and, in most years, more wheat altogether than any other continent.[22] It is equally surprising to learn that the Soviet Union, before the war, produced about as much wheat as is grown in North America and that her bumper crop of 1479 million bushels in 1937 was slightly larger than the 1947 record in the United States.

Europe, excluding U. S. S. R., is only two thirds of the size of the United States, but the former has over 400 millions of people, while the latter has about 160 million (1950). In order to get enough to eat, the Europeans must till their land thoroughly. While the wheat farmers on the cheaper lands of Kansas, the Argentine, or the prairie provinces of western Canada are by their extensive but inexpensive methods averaging 11 to 16 bushels per acre from land worth from \$20 to \$100 per acre, the careful English farmer, with a systematic crop rotation, is averaging 34 bushels or even more per acre on land worth over \$200. The western European tenant farmer may not make as large profits per acre as the American farmer, because he has to pay rent and his higher yield requires much expense for labor and fertilizer.

European wheat yields. The hills and the rain of northern and western England, Scotland, and Wales, and the rains of Ireland cause wheat growing to be of small importance in those parts of the British Isles. Most of the British wheat crop is produced in eastern England, which has the advantages of a drier climate, more fertile soil, and level land. In 1943 Great Britain harvested a wheat crop of 130 million bushels, or more than was produced by any U. S. state except Kansas and North Dakota. Great Britain's postwar production has been about one third larger than in the 1930's.

In northwestern Europe the use of much fertilizer, careful seed selection, and scientific crop rotation result in high yields; more than 40 bushels per acre in England, Denmark, and the Low Countries. But the total output, in spite of high yields per acre, is inadequate to meet the needs of the large populations of these countries. Thus, industrial Belgium, with 735 persons per square mile, ranks second only to Great Britain among the world's great importers of wheat. France, with only one sixth as much tillable land as we have, usually has a wheat crop of over 250 million bushels, or about 25% of the amount produced in the United States. French farms average 20 acres each and those of the United States average 174 acres. Stimulated by a high tariff the French farmers generally make their country about 90% self-sufficient in wheat and in good years export a little. Because of effective tariff protection, wheat is grown upon about one fourth of all arable land, including much rough and poor land. As a result, the French yield of 27 bushels per acre is the lowest in western Europe, yet it is nearly double the average yield obtained in our leading wheat-growing states of the Great Plains area.

The European wheat grower, who gets high yields on his high-priced home lands with their high rental, usually adopts frontier methods if he emigrates to the plains of the United States or Argentina where land is cheaper. The same process is repeated within the United States. Old states, such as New York, with an average yield of 25.4 bushels per acre in 1940–49, have through good care a higher wheat yield than the rich plains states of Kansas, 16.0 bushels, and North Dakota, 13.1 bushels.

Mediterranean countries. Spain, Portugal, Italy, and Greece, as well as parts of Tunisia and Algeria in North Africa, have ideal climate if enough rain falls, and wheat is the chief grain. But the percentage of tillable land is small, owing to the rough nature of the country; the yield is lower than in northwest-

[22] *Distribution of Wheat Production (Millions of Bushels)*

	1909–13 (average)	1935–39 (average)	1949–53 (average)
Europe[a]	1,348	1,595	1,590
Asia[a]	419	1,498	1,565
U. S. S. R.	759	1,240	1,021[b]
North America	899	1,086	1,679
World total	3,800	6,021	6,683

[a] Excluding U. S. S. R. [b] 1947–50.

ern Europe, largely because of inferior methods; and the amount produced is not sufficient for the dense population. Yet Italy, with a crop of more than 250 million bushels of wheat per year, produces about twice as much wheat per acre as North Dakota. In 1954 we saw a modern *road* being built. Earth loosened by pick, lifted by shovel, *carried on backs of donkeys.* By implication that tells a lot about agriculture in that medieval country.

Southeastern Europe. The only part of Europe (outside the Soviet Union) that has a wheat surplus in normal times is the southeast. Prior to World War II northwestern Europe received substantial shipments of wheat from the grain-growing plains of the Danube Valley in Hungary, Rumania, Yugoslavia, and Bulgaria. A drastic decline in this trade has followed the disorganization of war, the establishment of Soviet control over all these countries but Yugoslavia, their efforts to develop an economy with less emphasis on grain exports,[23] and their increasing population.

6. SOVIET WHEAT

The Soviet Union has more good wheat soils than any other country. Therefore it is a major producer. Yields, generally under 12 bushels per acre,[24] are the lowest of any leading country as a result of climatic limitations and poor production methods. Total production varies with the impact of wars, droughts, and politics. Following the decrease during World War I and the Revolution, production averaged 791 million bushels in the years 1925–29, about 4% above the 1909–13 level. The early 1930's brought drought, peasant resistance to forced collectivization, and a major famine in 1932–33. The Soviet system of collective and state farms, served by centralized machine-tractor stations, became sufficiently organized to produce bumper crops under the favorable weather conditions of 1937 and 1938. Annual average production rose to 1136 million bushels in 1934–38, declined catastrophically during World War II, and recovered steadily to a 1947–50 average of 1021 million bushels. Russia no longer is among the major exporters. This increase is barely sufficient to feed her increasingly urban population, growing at a rate of 1.5% per year.

The major wheat-producing area is the belt of chernozem soils stretching from the southwestern borders eastward into central Siberia. This is Russia's most productive agricultural area and includes nearly three fourths of the total cultivated land.[25] Climate in the better areas is comparable to that of our own northern Great Plains, but population density is 7 times greater,[26] a very significant fact for a land of drought. Winter wheat is predominant in the Ukraine, Russia's bread basket. Spring wheat, which accounts for about two thirds of the total wheat acreage, is the main crop in the area east of the Don and on into Siberia[27] where autumns are drier, winters are colder,

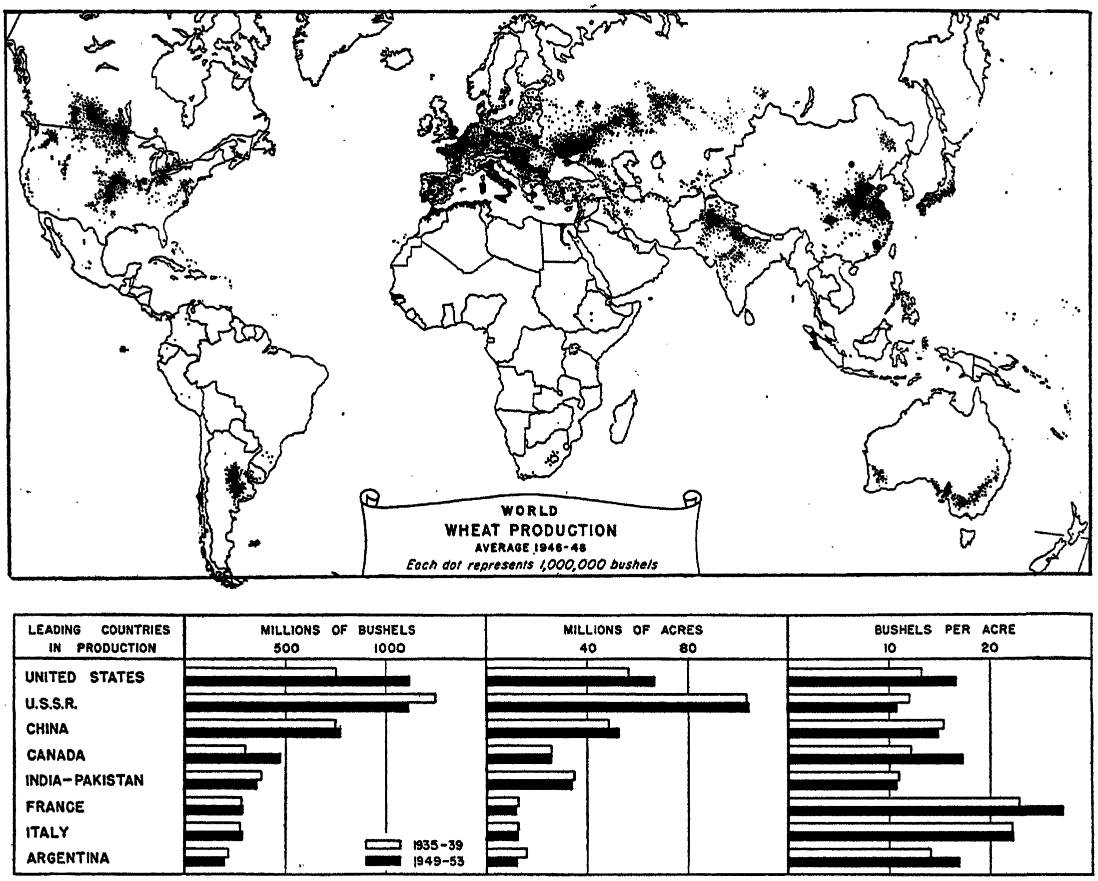
[23] Annual shipments of all grains from the Danube area to Europe averaged less than ½ million tons in 1947–48 in contrast to 2.9 million tons in the years 1934–38. U. N., Food and Agricultural Organization, *Grain Commodity Series,* Bulletin No. 18, May 1950, p. 34.

[24] Soviet figures on yield are generally much inflated, being based on estimates on the crops *before* harvest. The following are estimates of the U. S. Office of Foreign Agricultural Relations adjusted to a harvested basis. Average yield of wheat, bushels per acre: 1933–37, 11.5; 1935–39, 11.9; 1947–49, 11.0. Lazar Volin, *"A Survey of Soviet Russian Agriculture,"* USDA, Agriculture Monograph No. 5, 1951, p. 114. See also Volin, "Agricultural Statistics in Soviet Russia," *Foreign Agriculture,* March 1953, pp. 59–63.

[25] Naum Jasny, *The Socialized Agriculture of the U. S. S. R., Plans and Performance,* Stanford University Press, Stanford, 1949, p. 124.

[26] Rural population densities in the chernozem and brown-soil areas of European Russia range from 28 to 115 and average about 67 persons per square mile. In comparable areas of the northern Great Plains, densities range from 3 to 16 and average about 9. Russia also lacks large areas of the productive Corn and Cotton Climate regions so important in American agricultural production. Note the world climate map. Density estimates from M. Y. Nuttson, "USSR: Some Physical and Agricultural Characteristics of the Drought Area and Its Climatic Analogues in the United States," *Land Economics,* November 1949, p. 351.

[27] Excellent maps of all aspects of European agriculture are to be found in USDA, Office of Foreign Agricultural Relations, *Agricultural Geography of Europe and the Near East* (Miscellaneous Publication No. 665), Washington, 1948. The maps cover the major agricultural portion of the U. S. S. R. Those for wheat are on pp. 30–35.



This map shows how little of the world is really good land; also why tens of millions do not know what bread is. *U. S. Department of Agriculture.* The graph shows that France and Italy, the importers, lead the exporters in acre yield.

and snowfall is often light. Expansion of the Russian wheat area is difficult, owing to poor soils and short growing season on the north and aridity at the south of the major wheat belt. Under way are major shelter-belt and irrigation projects that aim at increasing wheat acreage and stabilizing production in the steppe areas around the Black and Caspian Seas[28]—with what success and at what cost no one yet knows. In regard to Soviet agriculture in general, Jasny concludes, "Foreigners are expected to believe the claims of both vast natural resources and great success in fulfilling the plans. Neither exists,"[29]—a conclusion shared by other experts on the Soviet Union.

7. WHEAT IN EASTERN AND SOUTHERN ASIA

China and Japan. While wheat is grown from Smyrna at the west of Asia to Hokkaido at the east, the small populations clustered thickly in the oases of the arid interior from Iraq to western China grow only limited quantities for their own use. About three fourths of Asia's production of wheat occurs in northern China and in northwestern India and Pakistan (see Fig. 88). Millions of Chinese depend upon wheat as their staple item of diet and have never seen rice. Wheat flour in China is used for unleavened biscuits, noodles, and boiled dumplings. Raised bread is seldom

[28] See, for example, USDA, Foreign Agricultural Service, "The Volga-Don Irrigation Project," *Foreign Agriculture,* October 1952, pp. 175–178.

[29] Jasny, *op. cit.,* p. 132. See also C. D. Harris, "Growing Food by Decree in Soviet Russia," *Foreign Affairs,* January 1955, pp. 1–14; and George B. Cressey, *How Strong Is Russia? A Geographic Appraisal,* Syracuse University Press, 1954.

eaten.[30] China *may* be the world's greatest wheat producer, but we do not know, for Chinese statistics regarding agricultural production in the past have been notoriously incomplete and unreliable, and are more so since the Communists' assumption of power.[31] South of the Great Wall in North China, large amounts of winter wheat are grown on the alluvial lands of the North China Plain and in the loess-covered hills to the west. Farther to the northwest a small spring wheat belt lies along the arid margin of Inner Mongolia. The Chinese laboriously produce a meager yield from farms that average less than 5 acres in size—this in a climate less favorable for wheat than that of our own wheat belts where 1200 acres is often regarded as the proper size for a family farm.

Manchuria, now part of China, could easily increase by severalfold its prewar crop of 30 to 40 million bushels.[32] It has suitable soil and climate for wheat, a relatively low population density (by Oriental standards), and the best possibility for increase in wheat production of any area in East Asia. For decades Manchuria has produced an important surplus of foodstuffs. Little of this will move to Europe since Manchuria is surrounded by food-deficit areas: the rest of China, Japan, and the Soviet Far East.

Much wheat is also grown in the humid rice climate of the Yangtze Valley in central China. Rice is the predominant and preferred crop. But winter wheat, planted on paddy land, is an important source of food in this densely populated area. Similarly, in southern Japan wheat is an important winter crop, following rice or, on the hilly land, beans and other vegetables. Spring wheat is grown in the north of Japan, especially in the less densely populated island of Hokkaido. Production increased rapidly in Japan during the interwar period, and the crop of around 55 million bushels is equal to about a tenth of Japan's rice crop.

India and Pakistan. In the Indian subcontinent wheat is chiefly grown in the dry Indus Valley, on the piedmont plains of the Punjab, and on the plateau east of Bombay. Practically none is grown in the hot, lower Ganges Valley or on the moist coasts of the Deccan Peninsula. In good years there has sometimes been a small export. Since the partition of India the "surplus" area in the Punjab lies mostly in Pakistan, and the Indian Union has been a regular importer of wheat. Even Pakistan imported substantial quantities in 1952 and 1953. Uncertain climate and large, rapidly growing population allow small chance for any dependable surplus for people outside this area. Famine is much more likely.

8. THE MANUFACTURE OF WHEAT PRODUCTS

Flour milling. The manufacture of wheat products has sprung up either near the wheat fields or along the line of wheat shipment. The waterfalls at Rochester, N. Y., and Niagara Falls, both being close to the Erie Canal, led to the early development of milling. Then the flour mills followed the wheat fields westward. After the adoption of the gradual-reduction process, Minneapolis, located at the falls of St. Anthony on the Mississippi River and near the edge of the Spring Wheat Belt, became the world's greatest flour-milling center. This city reached its peak during World War I with an annual output of 35 million sacks of flour. Since then milling in Minneapolis has declined while competing centers have expanded (see Fig. 81), owing to the rise of new wheat-producing areas, changes in marketing and consuming habits, and revisions of freight rates.[33]

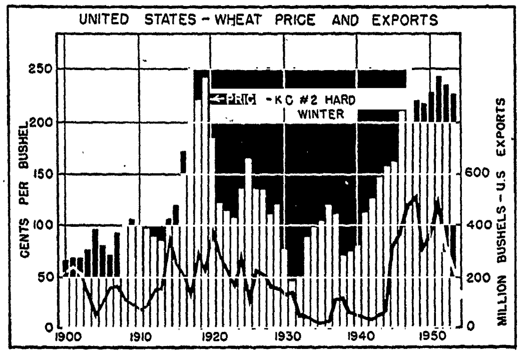
Buffalo surpassed Minneapolis in 1930 and remains the nation's leading milling center. It lies on the main spring-wheat route from Duluth and Fort William to the sea, and its huge elevators receive most of the American

[30] G. B. Cressey, *China's Geographic Foundations,* McGraw-Hill Book Co., New York, 1934, p. 102.

[31] 1952 production is estimated at 800 million bushels for China excluding Manchuria. USDA, *Foreign Crops and Markets,* Sept. 27, 1954, p. 330.

[32] Estimated production for 1952 was only 30 million bushels, *ibid.*

[33] See Alderfer and Michl, *op. cit.,* pp. 508–516.



Boom, bankruptcy, and football of foreign trade. What industry could stand such insane fluctuations?

This half-century of wheat price at Kansas City, after the farmer had paid the railroad to haul the wheat there, tells why we are in for price controls other than control by supply and demand. *U. S. Department of Agriculture*

grain carried down the Great Lakes each year. It is close to the great urban markets and also mills much Canadian grain in bond for export. Like other expanding milling centers, Buffalo has benefited from "milling-in-transit" privileges granted by rail and water carriers.[34]

Since 1900 the production of spring wheat has declined while the output of winter wheat has greatly increased. Mills in Kansas, Nebraska, Oklahoma, and Texas now produce about one third of the nation's flour. Kansas City, straddling the Missouri-Kansas border, near fields of oil and natural gas, is usually ahead of Minneapolis in flour production while Wichita, Salina, Dallas, Forth Worth, and Houston are other centers of importance in this southwestern winter-wheat area.

By-products. In various towns along the route of wheat shipment from the Mississippi valley to the sea, as at Battle Creek, Mich., there have sprung up manufactures of prepared breakfast foods, an increasing form of cereal consumption. These, however, use other grains by themselves or in combination with wheat.

The chief by-product of the U. S. flour mills, bran, the outer covering of wheat, is used as stock feed, especially for dairy cattle, in the same populous regions that buy the flour. Minneapolis and Buffalo, in particular, are well located close to well-established dairy industries.

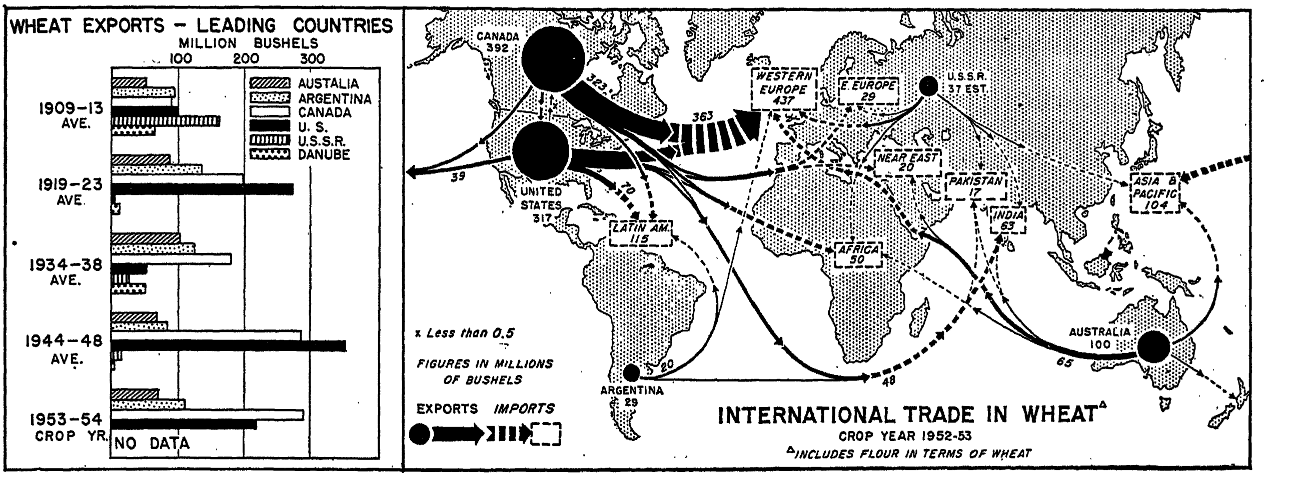
9. WHEAT TRADE AND THE FUTURE SUPPLY

Wheat is a leading commodity and by far the most important grain in international commerce. In the hungry postwar years nearly 25 million tons (930 million bushels) of wheat and wheat flour were exported each year. This is the largest amount on record and much above the 15-million-ton average of 1934–38. Although wheat is grown in many countries, over 40 of which have an annual crop of more than 10 million bushels each, exports come from a few surplus countries and move mainly to the deficit countries of western Europe. These constitute the "world" wheat market to a large degree, but small quantities go to many other areas (see Fig. 91).

Exporting countries. Most of the world's export wheat has come from two groups of countries: the four "overseas exporters"—United States, Canada, Australia, and Argentina; and the East European exporters—Russia, together with the four Danube countries, Rumania, Bulgaria, Hungary, and Yugoslavia.

In the four "overseas" countries export wheat is produced in the grassland areas opened to settlement during the last century, where topography is flat, soils are fertile, and the climate is good although not ideal for wheat. In these areas of relatively low yield per acre, mechanized farming methods result in high yields per man and produce large sur-

[34] Under transit privileges, wheat from point A may be milled at B and the flour shipped to C. The transport rate is based on the longer haul from A to C rather than on the more expensive combination of two shorter hauls—A to B plus B to C. As far as transport costs are concerned, flour mills can therefore be located at various points between wheat-producing areas and the flour-consuming districts. Transit privileges apply to many other commodities and have an important effect upon the location of industry and marketing centers. See Marvin L. Fair and Ernest W. Williams, *Economics of Transportation*, Harper & Bros., New York, 1950, pp. 360–361, 435–440.



This graph and map show the service of the United States and Canada in war periods and the decline of eastern Europe. In depression years Europeans ate more potatoes. *U. S. Department of Agriculture*

pluses of low-cost wheat. Canada, Australia, and Argentina are predominantly agrarian and pastoral countries with relatively small populations and generally export between 50% and 60% of their wheat crop. Canada is the most important, in postwar years producing and exporting upward of three times as much as either Australia or Argentina.

The United States differs from the other three in having a highly industrialized economy and a population of over 160 million. Our northeastern industrial region is therefore a wheat-deficit area, comparable to that of northwestern Europe, but supplied from the surplus areas within our own borders. In the interwar period our wheat exports declined to less than 50 million bushels a year in 1934–38, the lowest point since the Civil War. Drought, acreage restrictions, governmental efforts to hold our wheat prices above the low level of the world price, as well as our growing internal demand for wheat, all contributed to this decline in our exports. This was radically changed by World War II. Record-breaking shipments made the United States the leading exporter from 1945 until 1953 when Canada regained first place. A series of good crop years, government-guaranteed and rising prices, and an expandable technology for wheat production provided the internal base for these exports which were susidized to a considerable degree by our various foreign-aid programs. The parallel with the years following World War I is unmistakable. Will the coming years find a similar parallel in the historic 1930's?

The wheat areas of the East European exporters, the Soviet Union and the Danube countries, have a comparable physical environment to those "overseas"—flat, fertile grasslands with continental climate. Despite a much longer period of settlement, more dense population, and more primitive production techniques, they have, in the past, been important sources of wheat for western Europe. In the years prior to World War I, Russia became the world's leading exporter, displacing the United States from that position held since the development of the wheat trade in the nineteenth century. The Danube countries together were sometimes in second place and continued to ship substantial quantities of wheat to western Europe until World War II. Russia, however, virtually disappeared from the world wheat market[35] and, since their incorporation into the Soviet sphere (Yugo-

[35] In only five years between 1915 and 1951 did Russia export as much as 30 million bushels. Her largest exports, about 90 million bushels in each of the years 1930 and 1931, were for the purpose of obtaining needed foreign exchange for the purchase of industrial equipment, and took place at a time when starvation was imminent for many Russians.

slavia excepted), the Danube countries too have shipped little wheat to the west. At present, eastern Europe and the Soviet Union constitute a commercial wheat-producing area largely separate from the world market—with most of the production required for their growing and increasingly industrialized populations. But there is an export potential, especially in years of good crops, for production is large.[36] But it will be the decision of the Soviet dictatorship, based on its own political and economic interests, which may change this potential into actual exports of substantial amounts to the free world.

A number of other countries have exported varying quantities of wheat particularly in the prewar years. The Indian peninsula was an important exporter at the turn of the century but has been a heavy importer since 1945. Variable exports have also come from Turkey, North Africa, and small Southern Hemisphere countries, such as Uruguay, Chile, and South Africa.

The really significant facts about the wheat exporters are, first, their disappearance, and, second, all of them are practicing robber agriculture—removing and not replacing. This often encourages erosion by water and wind—skinning the continents. What will these wheat lands be in 50 years—100 years? West Europe's lands will still be fat—fattened in part by minerals from the grasslands by way of import grain fed to European livestock and then the manure put upon the European fields. The big export wheat lands are fertilizer mines, as now conducted.

Wheat-importing countries. The main function of the world wheat trade has been to supply the deficit of western Europe. In this area, as we have seen, wheat is widely grown as part of an intensive, diversified agriculture. Yields are high and total production is large (15% to 20% of the world crop) but insufficient to meet the demands of this highly urbanized area. As a result, in the prewar period, Europe took over two thirds of the total world export. Great Britain, the traditional exponent of free trade, has been the leading importer. With less than 10% of her population engaged in agriculture, no other major nation is so dependent upon imported food.[37]

Agriculture has remained more important across the Channel and, since the late nineteenth century, the farmers of most continental countries have received tariff protection from at least some of the competition of overseas agricultural imports. After World War I this effort to support agriculture as a way of life was intensified by nationalism and the desire for military self-sufficiency. Especially in Germany, Italy, and France wheat production was stimulated by higher tariffs, production subsidies, import restrictions, and regulations compelling millers to use a high proportion of domestic wheat in the production of flour. The result was a major increase in acreage and production[38] and decrease in imports so that, during the mid 1930's, Great Britain took more wheat than all the rest of western Europe. France has even become a net exporter in years of good crops—1950 and 1951 for example. Nevertheless, western Europe will continue as the main market for the world's export wheat. The degree of protectionism will naturally influence the amount of imports, but so also will the increase of population—and European population is increasing. Aside from the United States no other area has the standard of consumption to support a major import

[36] Export of only 10% of even the prewar production (Russia, Rumania, Bulgaria, and Hungary) would place 165 million bushels on the world market, —an amount equal to about one sixth of the world's annual exports in postwar years.

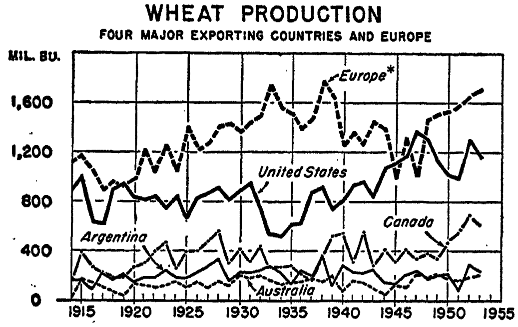
[37] Even after the efforts to expand domestic food supply during and after World War II, Great Britain imports 60% of her wheat and flour requirements (1951–53).

[38] It has been estimated that wheat acreage in these three countries would have been 7.5 million acres *less* than it was in 1939 "if national policy had not protected wheat farmers so effectively." Further, this acreage figure was equivalent to 11 million acres at the world average yield per acre. Wilfred Malenbaum, *The World Wheat Economy, 1885–1939*, Harvard University Press, Cambridge, 1953, p. 170.

of wheat. The period 1945–55 heard much loud talk about raising standards of consumption for the hungry half. Upping of food standards means wheat.

Since 1945 wheat imports to non-European areas have increased more rapidly so that Europe's share is now between 50% and 60% of the total. Imports into Asia, which had averaged 69 million bushels in 1934–38, were 250 million bushels annually in 1951–53. Although two thirds of these postwar imports went to Japan and India, almost every Asiatic country except China shows a substantial increase above prewar levels (see Fig. 91).

The future. There can be no doubt that enough wheat can be produced to supply the needs of those who can afford to purchase it during at least the next few decades. The present world acreage, 452 million in 1953, can be expanded and yields can be increased. The continuing problem of the commercial wheat producer is not shortage, but rather it is the long-term tendency to produce more than the "world" market can absorb. Since 1945 this "world" market has, in the economic sense, been virtually restricted to the four overseas exporters and western Europe. Little wheat moves into this "market" *from* other areas, while the substantial exports *to* other areas have been largely subsidized. These "other" areas—principally Asia, but also parts of Africa and Latin America—are the so-called underdeveloped countries, characterized by low standards of consumption generally, widespread malnutrition, and low per-capita consumption of wheat. Wheat production is significant in many of them and reaches major proportions in India, China, and Pakistan. However, they are primarily dependent upon their own production since, without outside aid, they can afford to buy but little wheat in the "world" market. This unfilled but ineffective demand continues to exist along with the tendency toward surplus.[39] Before we need concern ourselves with the ultimate limits of the world's wheat-producing capacity, we must deal with this anomaly. Here we are face to face with a fundamental problem of our time —the coexistence of surplus and hunger.



Europe (exclusive of U. S. S. R.), is the best of continents for its size. See how it rebounds from the war, partly due to U. S. aid, including fertilizer. The four rival exporters have had a terrible but rather unsuccessful time trying to agree on a world wheat-marketing plan. *U. S. Department of Agriculture*

[39] Exports from the four overseas countries declined from 979 million bushels in 1951 to 802 million in 1953. At the same time wheat stocks on hand (January 1) in these same countries increased from 1.7 billion bushels in 1952 to 2.6 billion in 1954. In June 1954 the governments of Canada and the United States cut the price of export wheat. These indications of a mounting surplus problem could be changed by short crops or costly governmental action, but they are disturbingly familiar signs to the wheat grower.

For a broad and thoughtful consideration of these various problems, see Malenbaum, *op. cit.*, Chapter XII, "Prospects for a Balanced Wheat Economy."

6· Rice—The Great Foodstuff of the Orient

1. THE IMPORTANCE AND USE OF RICE

The world's leading food. The old adage that bread is the staff of life is a striking example of the ease with which a local truth is perpetuated as a universal verity by people ignorant of geography. The fact is that hundreds of millions of healthy and industrious men have never seen bread as we in the Occident know it, but that is no sign that these men are savage, barbarian, or heathen. Throughout the Orient, from Pakistan to Japan, teeming millions obtain their carbohydrates from rice, which is low in gluten and will not make light bread. Among the world's great foodstuffs, rice and wheat are the unquestioned leaders.

Although rye, corn (maize), certain millets, and grain sorghums in some areas are dominant foods and are even preferred to other grains, approximately 4 out of 5 of the world's inhabitants prefer and consume predominantly rice or wheat.[1] The relative world importance of these two foodstuffs is probably indeterminate. More wheat is available for human consumption, since the quantity (measured by weight) of wheat generally exceeds that of rice[2] and less is lost in conversion to edible form. Nevertheless, rice is of predominant importance to a greater number of people than wheat. Cultivation of rice is an intensive, small-scale operation largely confined to areas of dense population. Therefore it occupies a major place in the agricultural activities of many more farmers than does wheat. In regard to consumption, about as many people eat rice as eat wheat. However, the number of people who obtain 60% or more of their food calories from rice greatly outnumber those similarly dependent on wheat. Wheat-eating populations are generally more prosperous, enjoy a more diversified diet, and are consequently less dependent upon their major grain. In the world at large, rice is more vitally important to a greater number of producers and consumers than is wheat.

The antiquity and uses of rice. The use of rice in the old lands of the East goes back into the unknown past. Centuries ago rice

[1] See Vernon D. Wickizer and Merrill K. Bennett, *The Rice Economy of Monsoon Asia*, Food Research Institute, Stanford University, Stanford, 1941, pp. 2–4, and M. K. Bennett, "International Contrasts in Food Consumption," *Geographical Review*, July 1941, pp. 365–376.

[2] Estimated Annual World Production of Leading Grains, 1950–52

	Pounds per bushel	Billion bushels	Billion pounds
Wheat	60	6.7	402.4
Rice	45	7.6	342.0
Corn	56	5.3	298.2
Oats	32	4.2	124.0
Barley	48	2.6	124.0
Rye	56	1.6	91.8

Calculated from USDA, *Agricultural Statistics, 1953*, pp. 6, 18, 23, 34, 43, 49.

spread from China and India to Egypt and North Africa, then in 1468 to Pisa in Europe; in 1694 the governor of South Carolina succeeded in cultivating it in his garden and thus started the industry in this country. A little rice is grown throughout nearly all tropical America and on both coasts of equatorial Africa and in the Congo forests. But no people depend upon it so fully as do those of southern and eastern Asia, with whom its use generally replaces that of wheat, potatoes, and, to some extent, meat also. The people of Europe and America use rice as an ordinary vegetable, as well as for pudding, and in place of the potato when that crop fails. Among these Western peoples rice is more a substitute food than a regular staple of diet. Rice is widely used as a staple article of diet in the tropics, especially tropic America. Along with beans it is the great mainstay of Puerto Rico, although almost none of it is grown there. It is much easier to boil rice than it is to bake bread. This, in combination with its good keeping qualities, may explain its predominance.

Since rice does not make light bread because it lacks the gluten, the Oriental boils the grain and eats it in that form. He flavors it with a bit of meat or fish if he can afford it; or he uses curry, a hot seasoning preparation made in endless varieties, especially in India. With peas and beans and some greens, rice furnishes almost the entire nourishment for hundreds of millions of people. Peas and beans are widely grown by almost all Eastern peoples who raise rice, and they are the substitute for meat, milk, and cheese of the West, while the starch of rice is the substitute for bread, potatoes, and many puddings as well. The unpolished rice eaten by the Oriental is much more wholesome than the shiny, white grain which most of us of the West insist upon eating. The process of polishing takes off the most nourishing part of the rice as well as the life-giving vitamins.[3] Polishing rice is one of the numerous cases in which appearance makes the purchaser select the really inferior article. The rice bran is a valuable cattle food and is exported as far as Europe. The straw is used for many purposes, including fodder for animals and for the manufacture of brooms, paper, matting, sandals, hats, and many other commercial and household articles used by the Orientals.

2. THE RICE ENVIRONMENT

Climate, surface, and soil. Among the environmental factors affecting rice production, water supply is most important; for the great bulk of all rice is grown under irrigation, the rice fields being submerged under approximately 6 inches of fresh, slowly moving water for at least 75 days. While the amount of water needed in a given area varies with such factors as rate of evaporation, relative humidity, and soil conditions, a total of 45 to 65 inches of water is generally required for rice production. If the rainfall is abundant and relative humidity is high, less water is needed from streams and other sources.[4] Furthermore, rice requires a mean temperature of more than 70° F. during the growing season of 4 to 6 months. Hence, rice is a product of the tropics and subtropics, most of it being grown in regions of reeking humidity with frequent, almost daily, rains. In such a climate all the European grains—wheat, barley, rye, oats, and buckwheat—fail miserably, and corn is far from its best, owing to the bad effects of the moisture. Rice is to the regions with moist summers what wheat is to the regions with a dry summer.

Level land must be had for irrigation, and

[3] Calories do not tell the complete story of nutrition. They must be made alive with vitamins found in living food, such as uncooked greens, most husks (such as bran), the outer coating of rice, milk and its uncooked derivatives, orange juice, and all fruits. Hence the practice of giving orange juice to the baby that is fed upon dead (pasturized or condensed) milk.

[4] One finds irrigation companies in Louisiana, one of the wettest spots in the United States. Rainfall during the rice-growing season amounts to about 20 inches, and man must provide an additional 25 to 30 inches of water, which is pumped from streams and wells onto the riceland. Rice does not require high humidity, for it thrives in the dry summer heat of the Nile, Po, and Sacramento valleys. However, most of the world's rice is produced in areas receiving over 40 inches of precipitation per year.

Thailand—the Oriental woman plants rice, man supervises. Note planter's foot. Compare Fig. 97 *bottom. USDA Foreign Agriculture*

where it is lacking man must create it artificially, as he has done by laboriously building terraces on the steep hillsides in many parts of Japan, China, the Philippines, and the East Indies. Although rice is grown on a variety of soils, there must be an impervious subsoil to prevent the loss of valuable irrigation water by seepage. Ideal soil conditions are found on many an alluvial plain, where a topsoil of fertile and friable silt has been deposited above a layer of impervious clay.

Although rice is now produced in the tropic and subtropic lands of every continent, over 90% of the world's crop is grown in southern and eastern Asia.

Rice and the monsoon. In the summer season the Asiatic monsoon, a seasonal wind, a gigantic sea breeze, blows inland from the warm, moist Indian and Pacific oceans across all coastlands between western India and northern Japan. To southern and eastern India, Ceylon, Burma, Thailand, and Indochina, the Philippines, China, southern Korea, Japan, and the windward side of many East Indian islands it gives a heavy, warm midsummer rain.

The Asiatic summer rain produced by the monsoon is one of the greatest factors in the relation of man to the earth. Southeastern Asia and adjoining islands, the region of monsoon climate with rice the leading cereal, is the home of more than half the human race. One of the important reasons why this small fraction of the world holds so many of its people is because the monsoon climate has rain at the season of greatest heat and growth rather than in the cooler period of least growth, such as results from the winter rainfalls of California, Spain, Italy, Australia, and Chile.

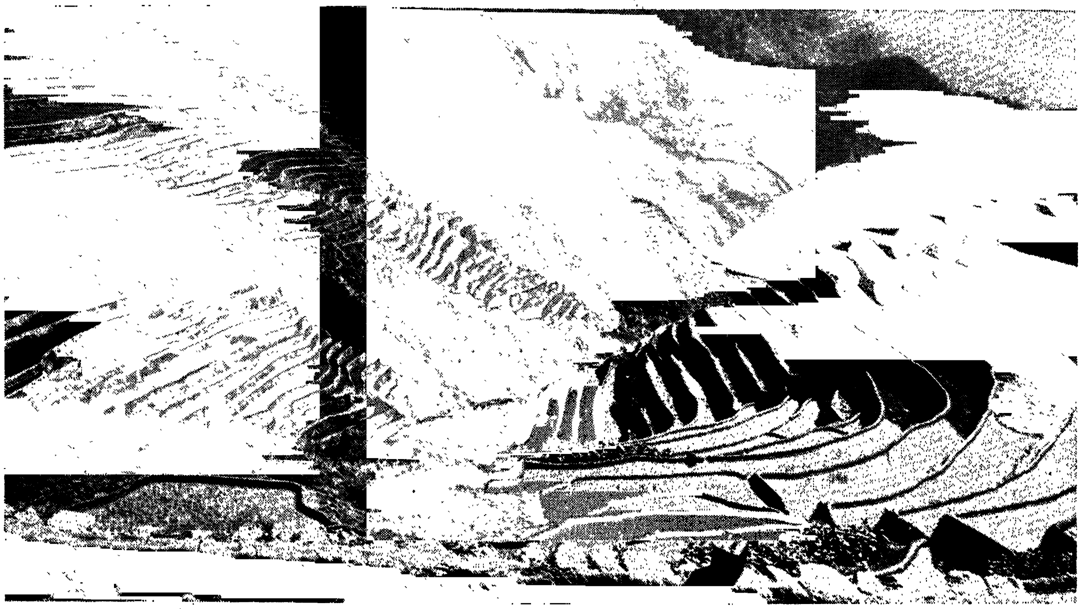
The climate possesses first the intermittency to compel people to work for the nonproductive season of drought and then rainfall enough to permit great production and thus great food supply and its resulting human numbers. The rainfall is regular over large areas—a factor of inestimable importance.

Rice flourishes in the wet summer due to the monsoon, and in these parts of southeastern Asia, where the moisture is sufficient to its satisfactory growth, rice is the mainstay of the population. Rice is the grain of the moist low plain, and contrary to the general opinion it is a luxury to millions of poorer Chinese and Japanese who live on the cheaper and less desirable millet, European small grains, corn, sweet potatoes, and other cereals not known in America.

These European and other grains are raised where rice is impossible of cultivation. In the Indus Valley and the plateau of peninsular India wheat, millet, and sorghums are the major foodstuffs. The same is true in North China where low rainfall and porous soil make rice unimportant.[5] Moisture and soil conditions rather than temperature are the major limiting factors, for we find rice grown in Manchuria and even in Hokkaido where the climate is similar to that of New England.

Wheat and barley are often grown on riceland in winter, and the two grain crops per year measure the intensity of production. To

[5] The leading Western authority on agriculture in China divides that country into two major divisions; "Wheat China," north of the Yangtze valley, and "Rice China." J. L. Buck, *Land Utilization in China*, 3 vols., University of Nanking, China, 1937.



These terraced rice fields made by the Ifugaos tribe in the mountains of Luzon are one of the most astonishing monuments of careful human labor. These steps with their annual rice crops have been on these mountainsides for several centuries. We have seen them 2000 feet up in South China. In the sweat of their faces do they eat rice.

Some Americans whose farms have been allowed to wash away in a single generation call these Filipinos "savages." Savagery exists in several areas—one is agricultural savagery. In that field the Ifugaos are highly civilized and those who let their farms wash away . . . ? Land ownership in the United States is still a license to kill. *Soil Conservation Service*

get the two crops in one year requires the laborious time-saving device of transplanting the rice *by hand* from seedbed to field. This practice saves weeks and makes possible the *two* crops on the same land.

3. THE PRODUCTION OF UPLAND AND LOWLAND RICE

Upland rice. The thousands of varieties of rice owing to its age-long cultivation are divided into two classes, known respectively as upland rice and lowland rice. Lowland rice must be grown in water, while the upland rice is grown much like wheat or oats and is grown chiefly where population is sparse, land is abundant, and rain is heavy.

Upland rice is grown in the system of shifting cultivation found in all sparsely populated regions of the Tropic Forest climate. Here dense vegetation covers every foot of land except where man has fought it back. When a new rice field is wanted, the dwellers in the thatch huts will begin the year by cutting or burning the forest. Among stumps and prostrate logs, the upland rice is planted in holes

Paddies in ~~Thailand~~. Enough monsoon to keep the paddies full—God's rice land. *USDA Foreign Agriculture*

made with a sharp stick and filled by the bare foot. As young rice is much prized by wild animals, from the elephant down to the small rodents, the clearing must be watched until the harvest. After two crops are taken, the field is abandoned for a fresh field and the tangled jungle or grass promptly reclaims the land. This is the age-old primitive agriculture, so common in the wet tropics as to be known by many different names in various parts of the world (p. 57).

Upland rice sometimes is grown with greater care on land that cannot be irrigated in a region where all land suitable for lowland rice has been appropriated, as in Japan. As a general rule, however, methods of upland-rice culture are primitive and careless, and the yields are uncertain and low. In the aggregate, upland rice accounts for a very small portion of the world's total rice supply.[6]

Lowland rice in densely peopled lands. Most of the countries with monsoon climates are too densely peopled to grow their rice in this crude way. In such localities the land once cleared is kept in cultivation for centuries. Such dense populations nearly always grow the wet variety of rice, because of its greater and more certain yield. Few crops are surer than irrigated rice, and few more uncertain than upland rice, which likes a ½ inch of rain per day to do its best. Lowland rice must be grown by irrigation, and the devices and structures used in fitting and keeping the land for this service are among the greatest monuments of human diligence in the world. They are certainly the most creditable constructions produced by tropical peoples, the only rivals being the slave-built monuments of tyrants. In Ceylon, for example, the railway that goes from the seacoast to the highlands goes through an irrigated plain divided by low banks into ponds of small area—rice fields, each of which has by great labor been leveled so that the water may be of uniform and proper depth for rice growing. As the railroad climbs the slopes of the hills the rice patches continue, with smaller area and higher banks, turning at last into a giant flight of gentle water steps, one of the most beautiful landscapes that the world possesses.

Many mountains in Java are similarly terraced for rice far up their sides; and, in China and Japan, similar stupendous works have been constructed for the support of the populations, which, like those of Java and of Ceylon, are very dense and mainly dependent upon agriculture in which rice is the staple food crop. In Japan 55% of the cultivated land is in these irrigated paddy fields. The similar work of the Philippine Igorotes, whose steep terraces have stood for centuries—and who have themselves stood for centuries and whom we have called savages—should make us wonder what they would call us if they saw the gullied ruins of American corn and cotton fields.

In the rice paddy, water must be maintained at the proper level during the growing of the plant and drained off prior to harvest. In many areas, especially in China and Japan, irrigation of the paddies is "artificial" and requires much labor. Intricate canal systems divert water from streams or small storage reservoirs to the paddies. In terraced areas, the small dikes around each terrace must be carefully maintained to prevent breaks which would start a destructive avalanche of mud and water headlong down the steplike slopes. In low-lying areas, water must often be pumped into the paddies, generally by means of primitive wheels or other devices powered by sweating Orientals. Sometimes it must be similarly pumped out again as harvest time approaches.

Artificial irrigation is by no means universal. Much rice in India and Southeast Asia is dependent on "natural" irrigation—the rain

[6] Among the countries reporting information on upland rice, the proportion of the total rice area occupied by upland rice varies from 2% in Korea to about 10% in Java, while the proportion of upland rice to total rice production is even smaller, owing to the low yields obtained from upland rice culture. Wickizer and Bennett, *op. cit.*, footnote 6, p. 11.

Thump, thump, thump. The sound resounds throughout a half-million villages in monsoon lands as the women pound the day's ration of rice. In the damp climate it keeps better in the husk. *Wm. H. Koenig*

with a slit in it. Drawing the rice through the slit pulls the grains from the heads and allows them to fall into a receptacle. The grain at this stage is called paddy because of a close-fitting husk not unlike that which protects the oat kernel. As with oats, these husks cause the grain to keep much better than when the husk is removed and the final husking of rice for home use is usually deferred until the time of use approaches. Among the Oriental people the husking of the paddy to prepare it for food is a daily occurrence, commonly done by hand. One of the commonest sounds throughout the East, from Bombay to Manila and from the equator to Peiping, is the pounding of a heavy mallet or pestle as it falls into a vessel full of paddy in the process of pounding the grain and loosening the husk.[9]

4. THE SPREAD OF RICE GROWING

Lowland rice production is not only an agricultural activity, it is a way of life associated with Oriental peoples in densely populated countries. Therefore, its development in non-Oriental areas of favorable climate and soils has been surprisingly slow and small. The annual overflow of the Nile due to seasonal rains in central Africa, and the easy irrigation make rice as much at home in Egypt as it is in the garden farms of Japan, the lower valley of the Yangtze, or the terraces of Ceylon and Java. Rice has long been a staple in the Egyptian diet, and, in several recent years, a surplus for export has come from this crowded oasis.

Rice growing by Asiatic emigrants. The spread of East Indian laborers to the islands of Mauritius, Reunion, and Madagascar in the Indian Ocean has introduced rice growing there, while similar people, taken to the British colonies of Jamaica, Trinidad, Honduras, and Guiana, have carried with them the methods which their rice-growing ancestors have practiced for a hundred generations. British Guiana is an interesting example of these tropic American rice fields. Here, although the country is mostly uninhabited forest, there are large stretches where the level, alluvial swamp along the seashore has been utilized by the building of dikes, after the manner employed in Holland. The reclaimed land greatly resembles the rice-growing deltas of the rivers of southern Asia, and between 1898 and 1953 the acreage increases from 6000 to 140,000. Similar increases in acreage and production have taken place in other countries of Central and South America. But Brazil remains the leading West Hemisphere producer and exports from 5% to 10% of its crop.

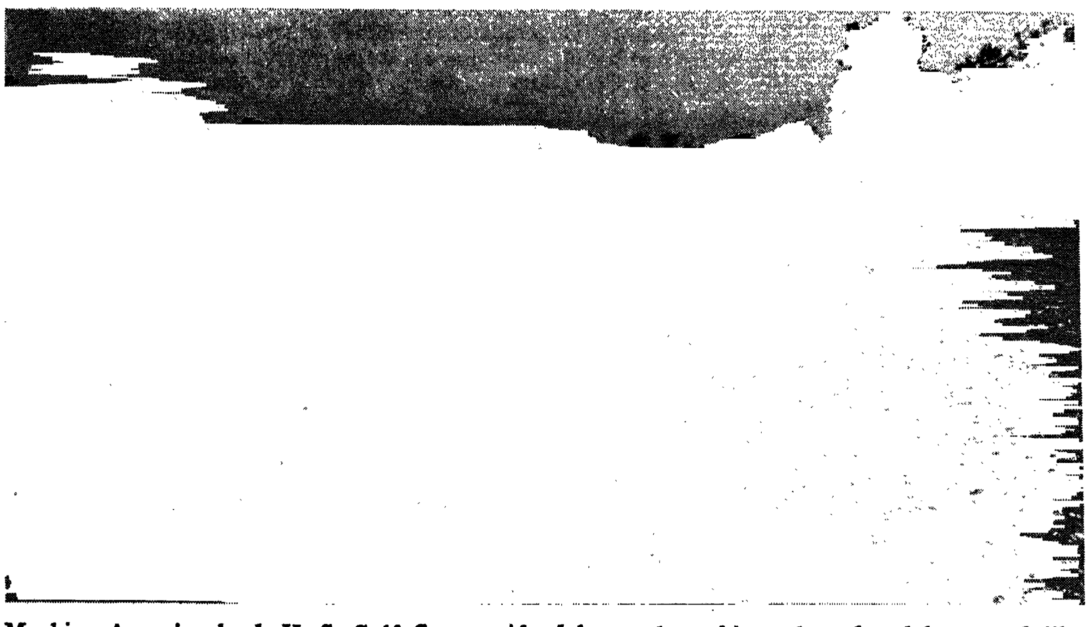
[9] See Franklin Hiram King, *Farmers of Forty Centuries, or Permanent Agriculture in China, Korea, and Japan.* University of Wisconsin Press, Madison, 1911 (reprinted by Organic Gardening Press, Emmaus, Pennsylvania, 1948). Although written nearly 50 years ago, this is still a classic description of Oriental agriculture. Excellent photographs of farm tools and methods are as applicable today as when they were taken. Oriental agriculture changes slowly if it changes. Most changes cost money.

Rice growing in Europe. Rice is a common, but relatively unimportant, item in the diet of most peoples in Europe and the Americas. But for certain groups it is a major source of food. It is of great value to dense populations because of the high average yields. In Japan (1945–49) rice averaged 3124 pounds to the acre, while wheat yielded 1242 pounds. In the United States, wheat made 1026 and rice 2117 pounds to the acre. For these reasons, the cultivation of rice has been taken up in southern Europe in most places where the water supply is sufficient for irrigation and where there are large numbers of people to be fed. In the Po Valley of Italy, a third of a million acres, equal in size to a typical American county, are carefully tilled in rice, and a substantial surplus is exported. Spain grows about a third as much along its Mediterranean coast, and Portugal is a significant producer. Since World War II acreage and production have expanded in these countries, in France, Greece, and even in the Danube plain in Hungary.[10]

5. GROWING RICE BY MACHINERY IN THE UNITED STATES

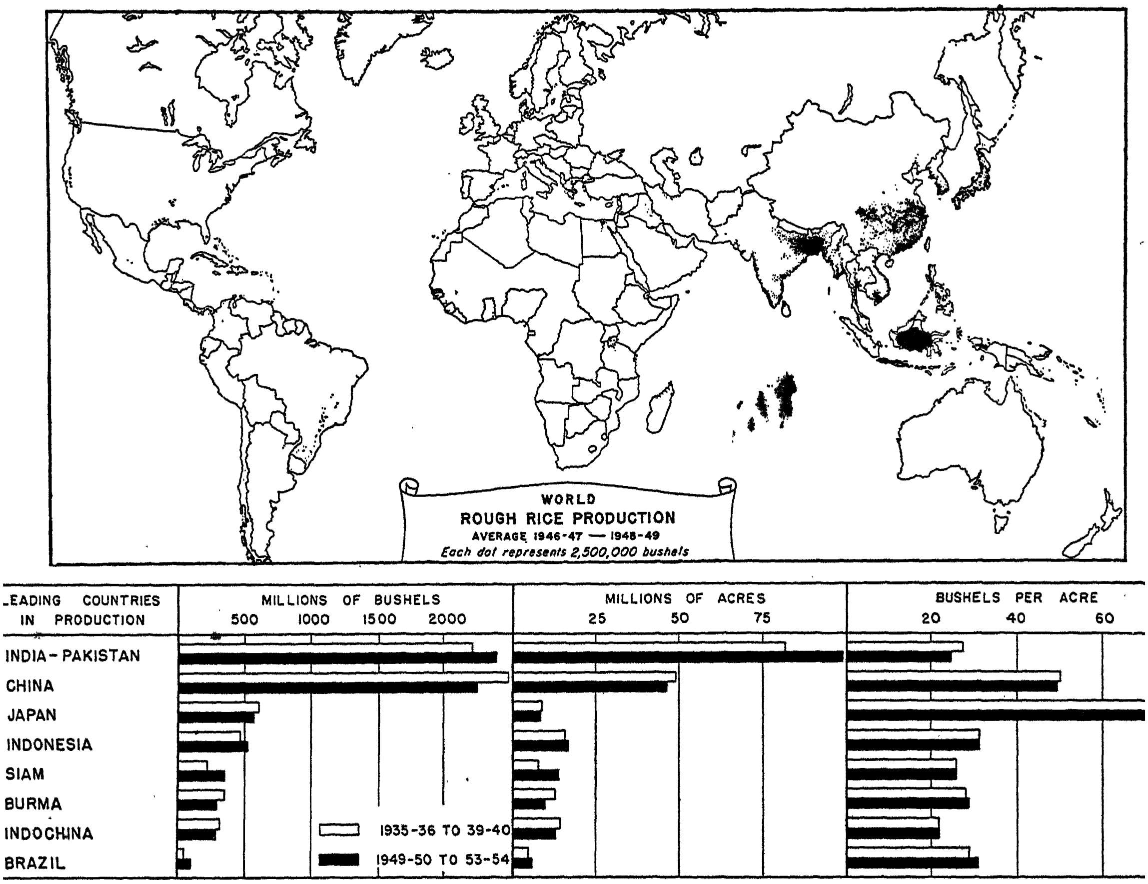
Rice and slavery. After the surprising success of the governor of South Carolina in raising a patch of rice in his garden in 1694, rice growing became an industry in that colony and in Georgia, since swamps along the seacoast and rivers could readily be diked off and cultivated by Negro slaves in the Oriental way. This was the chief place in the whole 13 colonies where Negro slaves were profitable in 1787, and it was owing to the influence of Georgia and Carolina rice growers that slavery received its recognition in the Constitution of the United States. Following the abolition of slavery, the rice industry declined, and today no rice is grown in this region.

Rice in the Machine Age. In the 1880's the prairies near the Gulf Coast in southwestern Louisiana and southeastern Texas became our leading rice area. Here are lands of wonderful levelness and with a very satisfactory clay subsoil to keep water from soaking



Machine Age rice land. U. S. Gulf Coast—ridged by road machine, planted and harvested like wheat, flooded by pumps driven by natural gas. ***Louisiana Experiment Station***

[10] Total acreage and production in western Europe about doubled between 1946 and 1954. In 1953 Europe was on a net export basis in sharp contrast to the heavy prewar import balance.



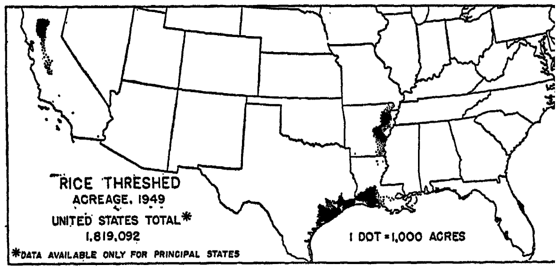
The facts of trade given in the table on page 103 give another method of showing some of the facts of this table. The most significant fact on the map is the small fragment of the earth's surface that suits this precious grain. This heightens the rivalry for the delta lands of Southeast Asia. *U. S. Department of Agriculture*

through. In most of this area powerful pumps, powered by natural gas, lift water from streams into irrigation canals, although in some places the water of artesian wells is used. The ground is plowed and harrowed with tractors and cultivators akin to those used in the preparation of large areas of wheat land. This is made possible by having the machine-made dikes of such gentle slope that equipment can be driven across them. After the water has been drawn off at ripening time, the ground is firm enough and the area large enough to permit the use of grain-harvesting machinery. As in the wheat belts, the combine is rapidly replacing the reaper-thresher combination. Similar conditions in the Grand Prairie of eastern Arkansas, where water supply is largely from wells, makes that state third in rice production.

The epitome of rice mechanization is found in the Sacramento valley, where the expansion of rice since 1912 marks one of the most recent steps in California's surprising capture of old-world crops. The level, new-made soil furnishes a fine site, and melting snows from the forest-clad mountains give plenty of water for irrigation. The physical geography is much like that of the Po valley in Italy, where an arm of the sea has been similarly filled with water-borne soil, now irrigated by the meltings of mountain snowfields. Production methods, however, are a world apart. In California, large-scale machinery prepares the nearly level rice land. Then heavy "dikers" drawn by two caterpillar tractors, dike the plowed fields, with the bulldozer adding the finishing touches. Low-flying airplanes may be used to broadcast soaked seed over the flooded "paddies" and to spread fertilizer and chemicals for bird and

weed control. With combine harvesting and bulk handling, 10 man-hours of labor suffice to produce 3500 lbs. of rice from an acre[11] in contrast to the hundreds of man-hours necessary to produce an acre of rice in the Orient.

Machine production and available land have allowed the United States to increase its rice acreage from about 1 million in the late 1930's to 1,972,000 in 1952.[12] Still we produce less than 2% of the world total, although, in postwar years, the United States has held third place among the world's exporters.



We grow about 5% of the world's rice, about 1/3 bushel per person, and export some. Nearly all the rest grows in a triangle—northern Japan, Bombay, and eastern Indonesia—monsoon lands. ***U. S. Bureau of the Census***

6. RICE TRADE AND WARS

Over 90% of the world's rice is both produced and consumed in Asia. Therefore, trade in rice is primarily the movement from surplus to deficit areas within that continent.[13] Prior to World War II, Japan, China, and India were the leading importers despite their large production. Smaller quantities were imported by

Table 6:1. Rice Exports,[a] Prewar and Postwar, for Selected Areas
(millions of pounds of milled rice)

Area	1936–40 av.		1946–50 av.		1953	
Indochina...............	3,233	16%	247	3%	450	4%
Burma..................	6,504	33	2,147	31	2,180	22
Thailand................	2,920	15	1,920	27	2,845	29
Korea...................	2,367	12	Import		Import	
Formosa................	1,427	7	50	1	129	1
Western Hemisphere......	418	2	1,582	23	2,179	22
All others..............	3,087	15	1,091	15	2,209	22
World total.............	19,956	100%	7,037	100%	10,092	100%

[a] Exports include re-exports. Much imported rice is re-exported from "All others," especially Holland, Belgium, Hong Kong, and Malaya.
Source: USDA Foreign Agricultural Service, *Foreign Crops and Markets,* July 26, 1954, pp. 80–82.

There is little connection between the amount of rice production and the amount of exports. The three leading exporters (1936–40) accounted for two thirds of the world rice export but produced only 12% of the world's rice. Their populations, however, are much smaller and less dense than the major importing countries. Similar circumstances underlie the importance of Australia, Canada, and Argentina as exporters of wheat.

Note the change in rice trade resulting from World War II: the decline in total world trade, the drastic reduction in exports from three Asiatic areas, and the rapid absolute and relative increase in exports from Western Hemisphere countries. But even in 1953 the Western Hemisphere *produced* only 6% of the world's crop of 267 billion pounds. How long will this export last? Even without much export from Indochina, Southeast Asia remains the major surplus area.

[11] Loren L. Davis, "California Rice Production," California Agricultural Experiment Service Bulletin No. 163, Berkeley, April 1950, pp 5–9, 29.

[12] Over half of our rice acreage (1954) is in the Texas-Louisiana prairies, 582,000 in Arkansas, and 461,000 acres in California. Calculated from USDA estimates.

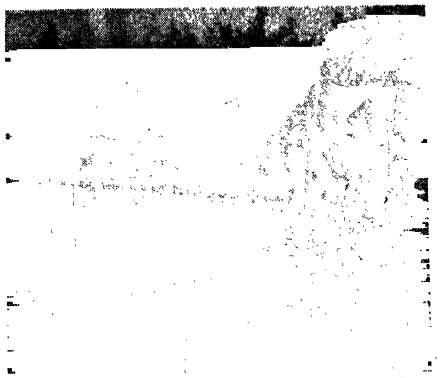
[13] This is in sharp contrast to the intercontinental movement of wheat from the world's frontier areas to the manufacturing regions of Europe and North America and, more recently, to the Far East. Much of the world's rice is consumed by the very individuals who produce it, and less than 10% moves in international trade. In most years about 15% of the world's wheat crop crosses international boundaries, and much larger amounts are shipped over long distances between producer and consumer within major producing countries.

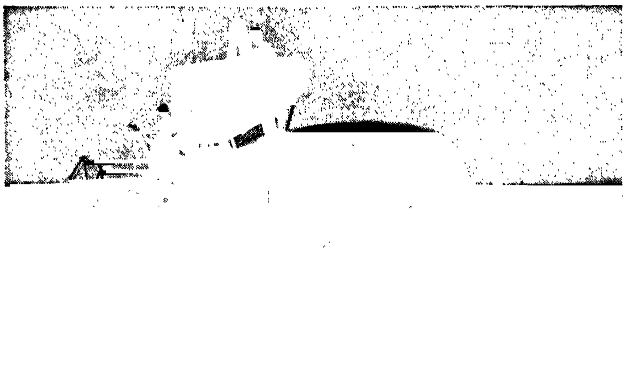
peoples whose plantation agriculture or mineral production were important—in Ceylon, Malaya, and parts of the East Indies. Southeast Asia was and remains the major surplus area for export. In the rich alluvial valleys of the Irrawaddy River in Burma, the Menam in Thailand, and the Mekong in Indochina, natural conditions favor rice production, and the population is less dense than in other Oriental rice areas. These countries together, with only 10% to 12% of the world's rice production, have consistently supplied about 60% of the exports (see Table 6:1). Two Japanese colonies, Korea and Formosa, were the other important exporters. By the late 1930's they supplied nearly all Japan's import requirements, amounting to about one fifth of the world total, and made her virtually independent of rice from Southeast Asia.

In addition to supplying her own deficit areas, Asia shipped rice to many other parts of the world. The major intercontinental movement was to western Europe, chiefly from Burma and Indochina. Rice from Southeast Asia also moved to the Caribbean, the major deficit area in the Western Hemisphere, where it competed with exports from the United States, Brazil, and several other nearby countries.[14]

This pattern of world trade, fairly simple in its major outlines, was drastically altered by the Japanese conquest of Southeast Asia in 1942. Acreage and production declined in this area while expanding in India and non-Asiatic countries under Allied control. Importing countries strove for self-sufficiency and new exporters emerged.[15] Events since the war have delayed the return to prewar trade patterns. Exports from Indochina, Korea, and Formosa have remained insignificant. Asia as a whole reversed its position and was a net importer between 1945 and 1951, while exports from the Western Hemisphere countries increased sixfold above prewar levels.

Nevertheless certain basic conditions remain the same. Asia still produces over 90% of the world's rice, Southeast Asia remains the major surplus area, and other countries in Asia are the leading importers. Short of a drastic revolution in eating habits and agricultural practices in many parts of the world, rice production and trade will continue to be dominated by Oriental stomachs and muscles unless the stomachs become too numerous.





(Left) The Oriental coolie on his tread mill—there are hundreds of thousands of him—lifts water 3 or 4 feet from a stream to the rice paddy. This might be in India, Malaya, Indonesia, China. (Right) A combine harvesting rice on the level plain near the Gulf Coast. Compare this with Asiatic scenes in this chapter. Combine gathers hundreds of times as much rice as the Ceylonese with the sickle. Ceylonese man's wage must be low.

[14] Cuba is the major importer in the Caribbean and preferential tariffs were necessary to assure the United States an important share in that market in competition with the cheaper rice from Southeast Asia. The Oriental peasant on the other side of the ican farmer. But compare the wages of the two.

[15] See Vernon D. Wickizer, *Rice in the Western Hemisphere: Wartime Developments and Postwar Problems,* Food Research Institute, Stanford University, Stanford, 1945.

7· Corn, Rye, Oats, and Other Cereals

1. CORN (MAIZE)

An Indian gift to the Caucasians. Corn and potatoes were two of the greatest discoveries of Columbus. Corn had long been the great food crop of ancient Maya, Aztec, and Inca, and of many less-civilized Indian tribes throughout the New World. This gift was first brought to the attention of Christopher Columbus on November 5, 1492, and the great discoverer found it to be a common crop in the West Indies. Prehistoric graves in the New World indicate that different types and varieties of corn have long been adapted to a variety of environments—the high Andes, the wet tropical lowlands of Central and South America, the dry uplands of Mexico and western United States, and the humid areas along our Atlantic and Gulf coasts.[1] Much of the modern corn grown in these areas has been derived from these ancient adaptations.

If you have done wrong to a man, you have an impulse to do it again to prove to yourself that you were right the first time. Having stolen the best of continents from the Indian, we have great difficulty in doing him justice or appreciating his achievements. In corn, Melvin R. Gilmore, of the Heye Foundation, New York, says that the Indian had under cultivation, when the white man came, the five different types, each subdivided into many varieties and growing far beyond what we consider the Corn Belt. Mr. Gilmore laments that the white man was not intelligent enough to begin where the Indian left off. Instead, we took Atlantic-coast corn west, then wondered what was the matter—and called the Indian a savage.

The value of corn to the settlers of America. When the first English settlers landed in Massachusetts and Virginia, the Indians presented them with ears of this valuable grain, which the settlers called Indian corn, *corn* being the English word for grain. The colonists, to their great benefit, at once began to cultivate it, because it was so much easier for them to grow than wheat, barley, rye, and oats with which they had been acquainted at home, and which required smooth, well-

[1] George F. Carter, "The Role of Plants in Geography," *Geographical Review*, January 1946, pp. 122–127.

Corn and its cultivation apparently spread through the Western Hemisphere from somewhere around the central Andes. However, we are less sure about its ultimate geographic and botanic origin than we thought we were 10 or 20 years ago, and the long-held belief in its American origin is being questioned. Scientists have thus far failed to prove corn's ancestral relationship to wild plants in this part of the world. Also there is accumulating evidence of its antiquity in parts of Asia—this latter despite the continuing belief that the corn now grown in the more populous parts of Asia has been derived from Caribbean types introduced after the discovery of America. See Carter, "The Origin of Maize," *Geographical Review*, April 1951, pp. 338–340.

This says *corn,* but it really is the agricultural geographer's spring calendar. Nearly all spring-sown crops follow closely. *U. S. Department of Agriculture*

cultivated fields. The new settler copied the Indian and in his "clearing" planted corn among the stumps or even the standing trees, deadened by girdling. A little rough cultivation produced a yield of corn twice that of more carefully tended small grains. Unlike the latter, ripe corn could stand a month or so in the settler's field undamaged by wind and weather, awaiting his convenience to harvest it. Once harvested it kept easily and could be served as food in many forms—as parched corn, the hunter's standby, made by heating the whole grain in a frying pan or over an open fire; as hominy, which is the cracked corn thoroughly boiled; as mush (samp), made by boiling the meal; or, finally, as cornbread.

These characteristics of corn, as crop and food which made it so valuable to our early settlers, explain in considerable measure its importance as a food crop in many rough and out-of-the-way areas of the world today.

Corn varieties, environments, and areas. As a result of the remarkable development of corn by the Indians more than four and a half centuries ago and the discoveries of modern plant breeders, man has available today a great diversity of types of corn, permitting production under widely different environmental conditions. Thus, some dwarf varieties grow less than 2 feet tall and mature in 60 to 70 days, while others achieve a height of more than 20 feet and require 10 to 11 months to reach maturity.[2] Corn is now produced from 58°N. Lat. in Canada and Russia to latitude 40° in the Southern Hemisphere. It is grown below sea level on the plains near the Caspian Sea and at elevations of over 12,000 feet in the Peruvian Andes. Drought-resistant varieties are grown by the Hopi, Zuñi, and Navajo Indians in the semiarid sections of Arizona and New Mexico, and corn is also grown in tropical Hindustan, which has more than 200 inches of rainfall a year. No cereal is cultivated under such diverse climatic conditions, none is distributed so widely throughout the world, and only wheat and sometimes rice occupy larger acreages.[3]

In those regions that produce most of the world's supply, corn is a warm-weather plant requiring high temperatures both day and night during the growing season. Virtually no corn is grown where the average summer temperature is less than 66°F., or where the average night temperature falls below 55°. Corn production, therefore, is unimportant at high elevations, as in our western states of Colorado and Nevada where the days are hot but the nights are cool. It is also unimportant in regions with a cool summer, such as England, Scotland, Ireland (in fact all North Europe), most of New England north of latitude 44°, and Canada, excepting a part of Ontario. In North Dakota, the corn crop approaches the Canadian boundary. The American Corn Belt, the world's greatest corn-producing region,

[2] See Leo J. Schaben, "Corn's Role in Feeding the Hungry," *Foreign Agriculture,* July 1948, pp. 139–145.

[3] Estimated world areas for leading grains, 1950–54 annual averages in millions of acres, were: wheat, 443; rice (1950–52), 236; corn, 216; oats, 131; barley, 121; rye, 97. In the years 1935–39 corn was slightly ahead of rice. USDA data.

Dusting cornfield for insect control. The farmer may come down the same rows tomorrow with the same tractor, cultivating 4 rows at a sweep. ***John Deere***

has an average summer temperature of 70° to 80°, an average night temperature exceeding 58°, and a frostless season of over 140 days.

For optimum growth and grain production, corn needs a plentiful supply of moisture well distributed throughout the growing season, maximum yields in this country being obtained where there is a monthly rainfall of 3 to 6 inches during June, July, and August.[4] In our Corn Belt the annual precipitation varies from 25 to 50 inches, 7 inches falling in July and August.

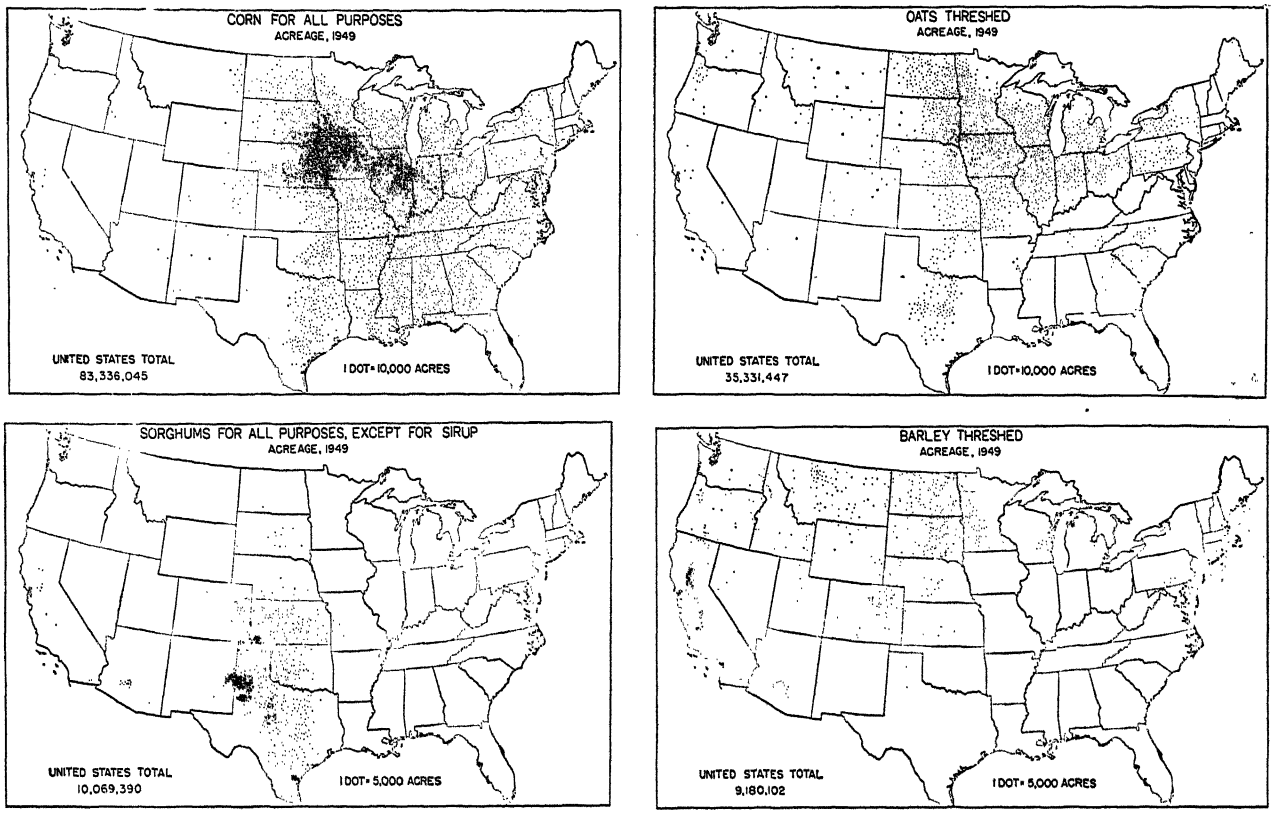
Although a lover of heat, corn does not do its best in the tropics or even in the prolonged summer at the mouth of the Mississippi River, or in Florida, where the corn grows tall but the yield of grain is low. It seems to require a seasonal warning that cold weather is approaching. It must get ahead of cold weather. The rapidly shortening hours of daylight in northern latitudes serve notice to the sensitive plant that winter is on the way, and cause it to turn its energies from leaf production to seed production. For this cause, apparently, the yield of grain is often larger on the northern margins of the Corn Belt than in its warmer parts or in the tropics, where length of day varies little from season to season.[5]

Although the growing of corn is very widely distributed, seven major zones of production may be recognized: (1) the U. S. Corn Belt, (2) the U. S. Cotton Belt, (3) the humid part of the Argentine Pampa, (4) the Danube basin and the area along the Black Sea in Russia, (5) the Mediterranean countries, (6) the highlands of Tropic America, and (7) southeastern Asia, especially China, Java and India (see Fig. 115). Among these major zones, the American Corn Belt is by far the most important and the primary basis for the United States production of 50% to 60% of the world's corn.

---

[4] The U. S. Department of Agriculture says that of all causes of damage to the growing corn crop, deficient moisture is by far the greatest. The average loss through deficient moisture over a 10-year period was estimated at 666 million bushels yearly.

[5] Through many generations of selection, the strains of corn grown in different latitudes from the Equator to the northern and southern limits of corn growing have become adapted to the length of day in the locality in which they are grown. When tropical varieties are grown in our Corn Belt, they do not flower until fall when the days are short. Plants of a tropical variety grown at Arlington, Va., subjected to an artificial 8½-hour day for 34 days beginning the last week in June, began flowering during the second week in August, whereas those grown with the natural day length did not flower until late in September. See Merle T. Jenkins, "Influence of Climate and Weather on Growth of Corn," USDA, *Yearbook of Agriculture, 1941,* p. 315.

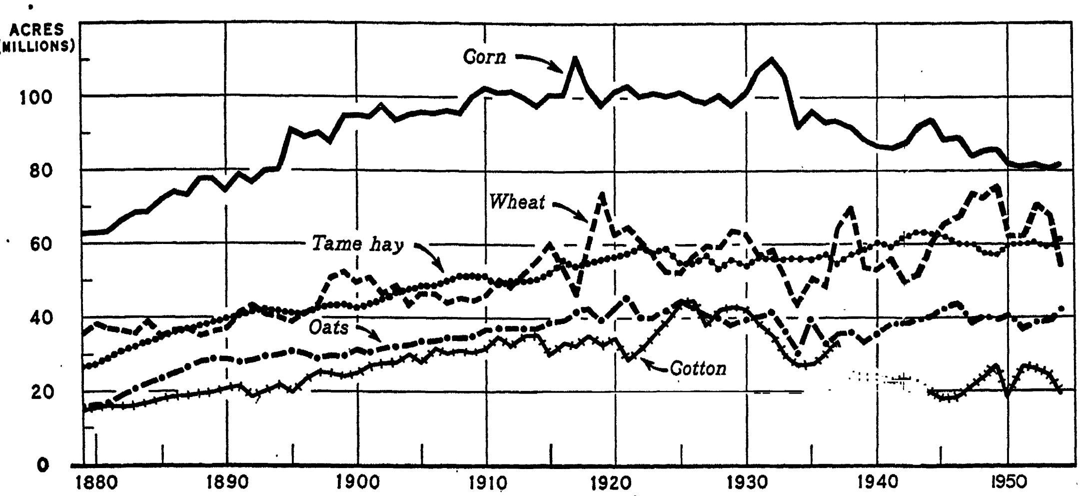


Corn shuns the hills of Ozarks, Appalachia, and the Lake regions, the sand of Nebraska sand hills, and Atlantic Coast Plain. Sorghum, the corn equivalent for dry plains, is a drought specialist. Compare barley and oats and see that barley takes the drier, colder edge. Oats chum well with corn in Corn Belt climate and crop rotation. *U. S. Bureau of the Census*

The United States Corn Belt. Corn is grown from the Gulf of Mexico to the Great Lakes, from the Atlantic Ocean to eastern Colorado, and in scattered areas beyond. But the region of greatest production is the Corn Belt, which reaches from central Ohio to central Nebraska and from southern Illinois to southern Wisconsin and Minnesota. This region is one of the finest agricultural sections in the entire world. Hundreds of miles of almost level prairie are rarely varied by undulations steep enough to interfere with the laying out of roads in a rectangular pattern at regular intervals of one mile. This soil that lies so beautifully for tillage is naturally fertile and stone-free. Glaciers repeatedly covered this area in the geologic past, leaving behind a thick mantle of rich, fine soil material, the natural fertility of which has been enhanced by the tall grass which covered most of it.

Serious droughts are infrequent in the Corn Belt. The abundant rainfall of summer comes in short showers which do not seriously interfere with agricultural operations, and the heat is sufficient to make a most excellent growth of corn.

Nowhere else in the world is this optimum combination of level terrain, fertile soil, and productive climate found over so large an area as our Corn Belt. Within our own country one does not have to go far beyond the Corn Belt borders before one or more of these favorable environmental conditions deteriorates. To the east lie the rough hill-lands of the Appalachians. On the south are hilly terrain and soils that are both less fertile and lacking in certain mineral elements. To the west is the uncertainty of decreasing and more variable rainfall. Northward the growing season shortens, soils become less fertile, and the glaciers left increas-



The amazing thing here is the small change, 276 million to 285 million acres in 43 years for 5 leading crops, 1910-53. Most of our real good land has been occupied for half a century. *U. S. Department of Agriculture and Bureau of the Census*

ing areas of rock, gravel, marsh, and lake.

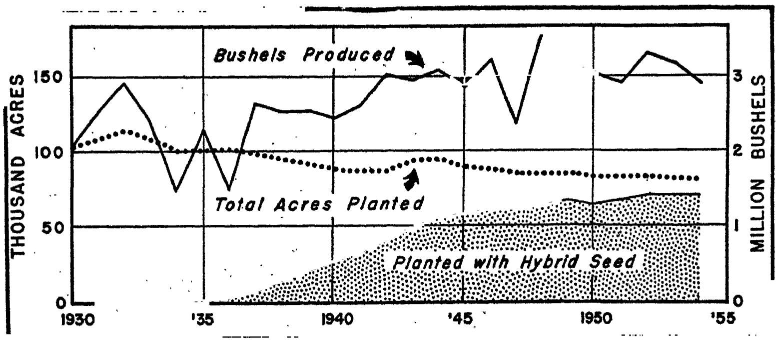
Relation of corn to other products of the Corn Belt. Although the most important, corn is by no means the only crop grown in the Corn Belt. It is the kingpin in a diversified system of highly mechanized, commercial farming. The basic crops, generally grown in rotation, are corn, small grains (usually wheat or oats), and grass (usually a legume). Pasture is important in the land-use scheme—either in rotation on cultivated land or permanent on land less suitable for the plow. A variety of other crops is also grown, of which the soybean, rapidly increasing in recent decades, is the most important.

The primary objective of Corn Belt agriculture is the production of animal products.[6] About 80% of our corn is fed to animals, much of it on the farms where it is grown, and sold in the more condensed form of cattle, hogs, poultry, sheep, or their products.[7] The biggest corn-growing states are also the ones which market the major share of the hogs and fat cattle.[8] In parts of Illinois and Iowa, where conditions for crop cultivation are especially favorable and transportation to nearby markets is cheaper, a substantial amount of corn is sold off the farm as grain. During the 10-year period, 1930–40, about 34% of the corn of Illinois was shipped out of the county where it was produced, in contrast to only about 9% in more distant Kansas and Texas. Much of this corn goes to the feed lots near the major meat-packing centers. These "cash corn" areas are also closer to the industries which use from 200 to 300 million bushels of corn in the production of alcohol in various forms, breakfast foods, corn meal, cornstarch, and corn syrup. Corn oil is also a brisk contestant in the hot race of vegetable oils toward their goal in the American frying pan. Other entries are the peanut, soybean, and cottonseed, all running strong and, unlike human beings, not perturbed by the prospective fate in the fiery furnace.

[6] The term "Corn Belt" is somewhat of a misnomer in view of the variety of crops and the emphasis on animal products. It is sometimes called the "Feed Grains and Livestock Region," and the system of farming has been termed the "Animal Specialty" type.

[7] This is in direct contrast to wheat, more than 70% of which is consumed directly as human food. Among the crops grown in the Corn Belt only alfalfa produces more pounds of digestible feed per acre than does corn. "But even a steer is not able to eat enough alfalfa to make it really fat." John D. Black, *et al., Farm Management,* The Macmillan Co., New York, 1947, pp. 263 ff.

[8] Seven states include most of the Corn Belt: Illinois, Iowa, Indiana, Minnesota, Nebraska, Ohio, and Missouri. In 1952, these states produced 69% of the corn and had within their borders 62% of the nation's hogs. But they had only 28% of all cattle and 26% of the chickens. Why this difference in importance of animals?



A windfall if there ever was one. Note relationships between the 3 items, especially acres and bushels. *Data from U. S. Department of Agriculture*

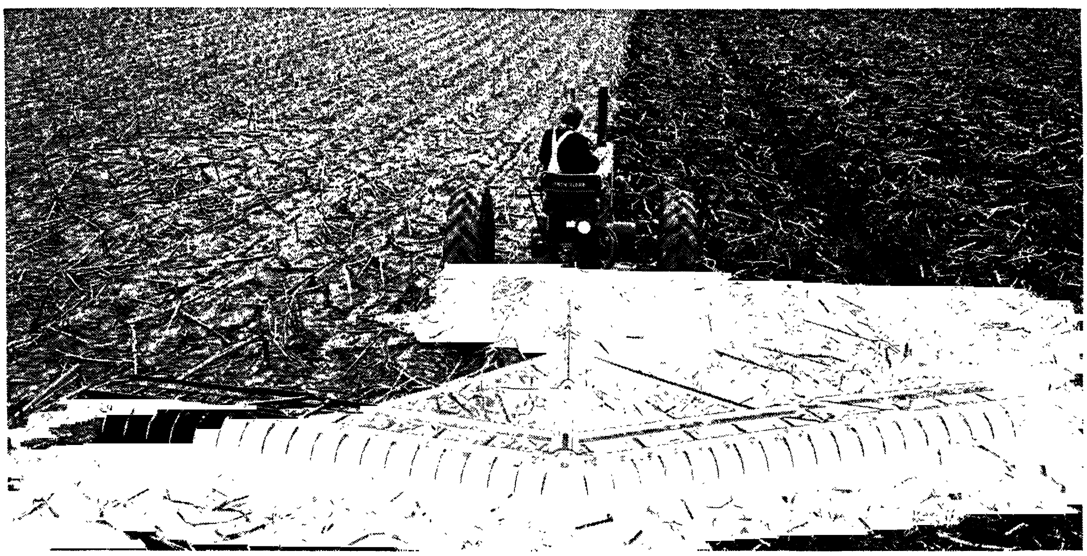
The improvement and extension of corn growing. Increasing productivity is characteristic of United States agriculture. For many crops, including corn, production has increased while acreage has remained stable or declined. Corn acreage reached 100 million in 1909 and a peak of 110 million in 1932. Since then acreage has declined. In the years 1928–32 we produced an average of 2.5 billion bushels from about 103 million acres. Between 1947 and 1951, production averaged just over 3 billion bushels from 84 million acres. This comparison means that a 44% increase in average yield (from 25.4 to 36.8 bushels per acre) resulted in 18% *more* production from 18% *less* acreage. The major factor in this increase in yield and production has been the rapid adoption of hybrid seed corn (see Fig. 110). Hybrid seed, pollinated under controlled conditions from selected strains, yields about 20% more grain per acre than ordinary open-pollinated varieties. In 1954, 87.1% of our national acreage was planted with hybrid seed, with the percentage rising to 100 in Illinois and Iowa.

With corn acreage less now than it was 40 years ago, there has been little expansion of important corn-producing regions. The only significant corn frontiers we have opened since 1895 have been those on the north, and the gradual extension of corn production northward has been chiefly due to the use of earlier maturing varieties. For example, a variety of corn known as Minnesota No. 13, which ripens in 13 weeks after it is up, was perfected in one of the Minnesota experiment stations and with a number of other varieties is steadily permitting corn to grow farther north. It has only been within the last four decades that South Dakota and Minnesota have become large corn-producing states.[9] South Dakota, long known chiefly as a wheat state, now grows more than 2 bushels of corn to every bushel of wheat, although the corn acreage has declined since the early 1930's. This northward movement of corn production has been closely related to the expansion of dairying in the Dairy Belt and the adjacent margins of the Corn Belt and the Spring Wheat Belt. Green corn, cut, chopped, and placed in the silo, may be kept moist, warm, and edible for cattle for one or two years. In this form, called *silage,* corn makes its greatest possible food return to ruminant animals. It is much used in the feeding of dairy and beef cattle, and, since it can be put away some weeks before it is fully matured, it can be grown much farther north than can the ripened grain, which can be kept only after fully maturing in the field.

The shorter summers in the area from Minnesota east to the Atlantic coast also favor the growth of sweet corn for table use. From the fields of sweet corn, truckloads of ears may go to the canning factory or the vegetable market, and the stalks are put into the farmer's

9 Production of Corn

	Minnesota		South Dakota	
	Million acres	Million bushels	Million acres	Million bushels
1907	1.6	43.6	1.8	47.1
1914	2.6	91.0	3.0	78.0
1923	4.3	154.7	4.2	145.1
1932	4.9	180.8	5.0	73.9
1954	5.6	271.6	4.1	111.9



Grandfather's new steel plow turned the earth upside down: buried vegetation. This marvelous disc harrow churns the top inches, works the vegetation into top layer where it can absorb the rain, hold the soil against erosion. Here last year's cornfield is being prepared for oats. ***John Deere***

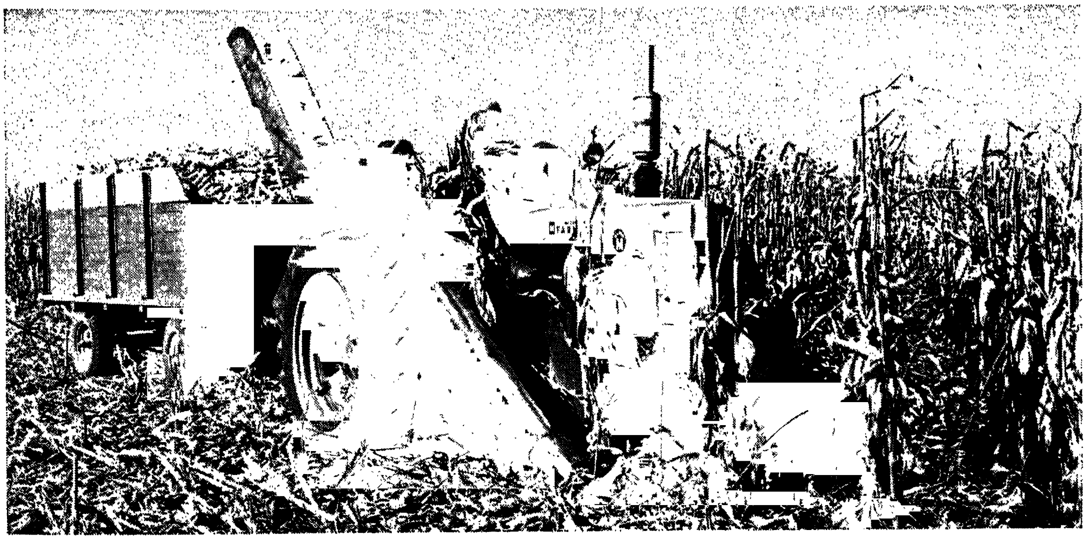
silo to feed his dairy cattle—an important fact in systematic agriculture.

West of the Corn Belt corn acreage fluctuates. Years of above-average rainfall tempt the farmers to expand, and years of drought force contraction.[10] Even in the High Plains some corn is usually planted as a "catch" crop because excessive rain in June and July may damage the wheat but favor corn. Also, even if the corn does not produce much grain, it can be used as silage or fodder and provides more cattle feed per acre than unirrigated pasture or hay. However, total acreage remains far below that of wheat, and many farmers have gone broke on the erroneous assumption that the Corn Belt can be moved westward.

Corn in the Cotton Belt. Corn is the second crop in importance in the cotton land of the South, but cotton is so overwhelmingly the main crop that the corn crop is often insufficient for local use, and import from the Corn Belt is necessary. Almost every farmer in the Cotton states cultivates a few acres of corn, but yields are low and the southern states produce less than one fifth of our corn crop from about one third of the national acreage. The corn is used mostly to feed animals, and, with the diversification of agriculture in the South and greater emphasis on animal industry, there has been some tendency for corn to displace cotton. The use of corn for human consumption is also more prevalent in the South than in other parts of the country, although much less so than in parts of Europe.

The Argentine Pampa. Argentina's Corn Belt lies west of the lower Paraná River in the Humid Pampa. Like our Corn Belt, it is a flat, fertile, grassland area with a humid climate (28 inches of rainfall on the west and 38 inches on the east) and a hot summer (temperature average from 71° to 75° F.). Here the similarity ceases. The Argentine belt is much smaller, occupying approximately 25,000 square miles, about one tenth of the area of the U. S. Corn Belt. It is roughly 155 miles from north to south and extends westward about 145 miles from the port of Rosario at the great bend of the Paraná. Droughts are much more frequent than in our Corn Belt, with the result that corn yields are more vari-

[10] The *Graphic Summaries* of various aspects of American agriculture published since 1930 by the U. S. Dept. of Agriculture and the Bureau of the Census contain many interesting maps of crop distributions and changes in crop acreages for various years and periods since 1910.



Unless strong wind knocks it down or raccoons carry it away, September corn will stand safely in the Corn Belt field until March. For most of American history the corn was cut, put into shocks, later husked by hand, ear at a time, thrown into pile on ground, picked up by hand, thrown into wagon. Cutting and shocking is a hard, hot, heavy, mean, sweaty, itchy job. Now look at the processes this buggy-riding boy saves as he sweeps up 2 rows at a time and hauls crop along with him. Therefore we can have big factories and big cities. This machinery feeds them, but it must have big fields and good surfaces. *International Harvester Co.*

able and both yield and acreage decrease sharply toward the west.[11]

The farming system is also much different from that of our Corn Belt. In the Argentine belt, corn occupies as much as 75% of the cropland and is produced for sale as grain by tenant farmers. Little is fed to animals or eaten by the population. Consequently, about three fourths of the crop is exported through the nearby ports of Rosario and Buenos Aires, most of it destined for northwestern Europe. Most of the crop is hard flint corn, which keeps and transports easily but is less suited for human consumption or animal fattening than the dent corn grown in the United States. It has small grains, well suited to poultry.

Even within the corn district, grazing remains important and more than 40% of the land area is devoted to pasture. However, there is little connection between cattle raising on the large estates operated by owners or managers and the cash corn growing on the smaller tenant-operated holdings of from 175 to 250 acres. Pasture and hay are the chief sources of feed for cattle, and hogs are pastured more than in United States. The number of corn-consuming hogs is less than half the number found in our state of Iowa, for hogs and cattle are not crops for the roving sharecropper. Argentina is said to suffer greatly from absentee landlordism and a malignant form of sharecropitis.

Since World War II Argentina's corn acreage, production, and exports have averaged half or less of what they were in the late 1930's. Unfavorable weather, government policies, and export problems have all contributed to this decline. It has been made easier by the dual economy in the Argentine corn district and the ease of shifting corn land to some other crop or to grazing use. Nevertheless, the potential remains for increased production and the re-establishment of Argentina as the leading corn exporter.

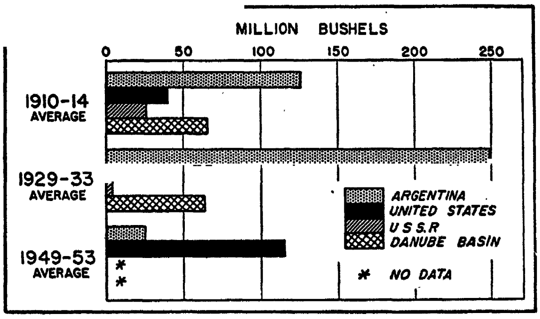
[11] At Pergamino, in the center of the Corn Belt, drought years occurred 3 years out of 25, and pre-World War II corn yields averaged 38 bushels per acre. Ninety miles to the southwest, drought years occurred 10 times in 25 years, and average yields were down to 17 bushels. Preston E. James, *Latin America,* Odyssey Press, New York, 1942, p. 355. See also *ibid.,* pp. 344–359, for a discussion of agriculture in the Humid Pampa from which material has been taken for this section.

Brazil. Brazil vies with Argentina for third place among the world's leading producers of corn, and from 1945 to 1953 production averaged about 240 million to Argentina's 140 million bushels. Three fourths of the crop is grown in the states of Minas Gerais, São Paulo, and Rio Grande do Sul. In contrast with Argentina, Brazil does not export corn, which combines with rice, beans, and tapioca to form the chief foods of the common people. Also more corn is fed to livestock. Brazil has more than 3 times as many people and 10 times as many hogs to feed. The Brazilian corn crop has greater cash value than the much-talked-of coffee.

The corn region of the Danube and the Black Sea areas. The corn zone second in importance to the United States Corn Belt is that of the lower Danube Valley and, continuing through Bessarabia eastward into the Soviet Union, along the north coast of the Black Sea and into the Caucasus. The crop in this region averaged around 630 million bushels a year before World War II,[12] less than one fourth of the output of the United States. Although occupied by several different nations, the lower Danube Valley is, like our Corn Belt, a single economic region with a significant food surplus in normal times. Large acreages of corn on the great fertile plains of Rumania and Yugoslavia gave these countries a production of from 150 to 200 million bushels each in the years before World War II, while Hungary and Bulgaria together produced about 125 million bushels. In all these countries the river plains are the major areas of production, but corn is also grown in the hilly and mountainous lands that resemble our Appalachia. Even on the better lands yields per acre are much lower than in the United States[13] as a result of inferior production methods and poorer climate. Droughts are also more frequent so that yields are more variable. The low standard of consumption in these countries means that much corn is eaten by the people, especially in Rumania where it has long been the chief foodstuff. Nevertheless, the major part of the production is fed to livestock. In prewar years much was exported to western Europe.[14]

Eastward along the Black Sea area of southern Russia and the Caucasus, increasing aridity and frequency of drought cause wheat to become more important than corn. In the lower Volga plains north and east of the Caspian Sea, the aridity is too great for tilled crops without irrigation.[15] In prewar years, Russian corn production about equaled that of Rumania. At the beginning of World War II, Russia annexed Bessarabia, one of Rumania's important grain-producing provinces, but postwar estimates of Russian production do not reflect this addition to her corn acreage (see footnote No. 12).

International trade in corn. In amount, corn is second only to wheat in the international grain trade, but only 8% to 10% of the world crop is exported. Like rice, most of the



A bunch of surprises. Why does not the king producer lead export all the time? Will we return to second place? Do we import or export meat? *Data from U. S. Department of Agriculture*

[12] Average production in millions of bushels, based on estimates for postwar years since official figures for some countries are lacking.

	1934–38	1945–49
Four Danube countries	510	359
Soviet Union	122	117

Calculated from: U. N., Food and Agricultural Organization *Commodity Series No. 18, Grain,* Washington, 1950, pp. 65, 66.

[13] Estimated yields for the four Danube countries (1945–49) was 18.5 bushels per acre in comparison with 35.6 for the United States and 48.7 for Iowa.

[14] Schaben, *op. cit.*, p. 143.

[15] This eastward succession of corn, wheat, and pasture regions here is an exact duplicate of the westward zoning of the same in Kansas and Nebraska.

world's corn is consumed within the areas of production, but by animals rather than humans. Three of the four major corn-producing zones previously discussed are the primary sources of export corn: Argentina, the Danube Basin, and the United States. During the past half-century there have been striking changes in the relative importance of these three exporters resulting from their geographic position, their contrasting systems of production and utilization, and the influence of wars and political considerations (see Fig. 113). At the turn of the century, the United States was the leading exporter, shipping nearly 200 million bushels each year. Prior to World War I, exports from the United States declined, and Argentina took first place and held it except for scattered years until after World War II. During the 1930's Argentina usually exported from 10 to 20 times as much as did the United States. In most interwar years, the Danube Basin was the second largest exporter. Since World War II, world corn trade has been about half the prewar volume and the United States has again been the leading exporter, probably a temporary situation.

For the past 50 years, exports from the United States have not exceeded the level reached at the turn of the century and, in most years, have been less than 1% of our crop. In fact, more American corn is usually exported in the form of meat and animal products than as grain. A part of the explanation lies in the interior location of our major corn-producing area. Corn for export is assembled in the markets of St. Louis, Kansas City, Omaha, or Chicago. From these points it usually moves by rail to the Atlantic ports between Norfolk and Montreal for overseas shipment, mainly to the countries of northwestern Europe where it is mostly fed to animals. Exports from the United States have been most important, both absolutely and relatively, in the periods following the two world wars. Since 1945, we have been shipping over 100 million bushels in most years—four times our average during the 1930's. A substantial portion of this has been for human consumption,[16] but this is of declining importance.

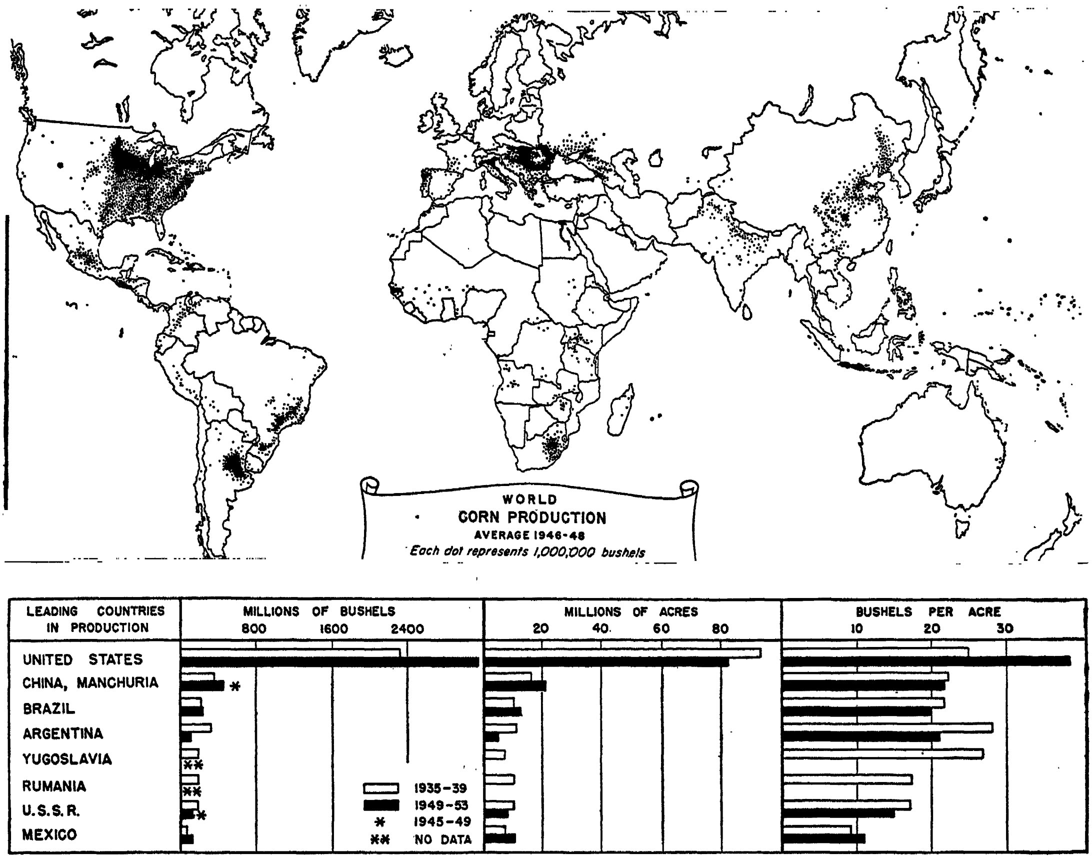
Argentina's position as the leading exporter in the interwar period was based on the coastal location of its Corn Belt, and the lack of large domestic utilization either for food or feed purposes. In the postwar period Argentina's exports have averaged about one fifth of the level during the 1930's. A series of drought years and transportation difficulties have been major causes of this decline. Also significant have been policies of the Argentine government which paid low prices to domestic producers while, at the same time, setting high prices on corn for export.

In the interwar period, production of the Danube countries together was about 20% more than Argentina's, but domestic utilization for feed and food kept the export surplus much lower, although usually larger than export from the United States. The postwar picture is clouded by lack of production and trade statistics from the Iron Curtain countries, but little corn has been shipped to the traditional markets in northwestern Europe, and what surplus there may be has been largely absorbed within the Soviet sphere.[17]

How long these postwar trade relationships will continue is difficult to say since political considerations (to say nothing of climatic factors) have such an important influence on exports from Argentina and the Danube. In the United States we have a rapidly increasing population, with a high standard of consumption, and with a high per-capita consumption of corn-fed meats. Under normal conditions, we can outbid others for our own corn crop, although the heavy exports in recent years have taken less than 3% of our crop. As long as world export of corn remains substantially below the prewar level, the United States could

[16] Schaben, *op. cit.*, p. 140.

[17] Yugoslavia, no longer an Iron Curtain country, exported 244,000 tons 1951–52 average. The efforts to collectivise agriculture in Iron Curtain countries, the plans to increase meat production, the urbanization of the population, and, above all, the overriding influence of the Soviet Union's self-interest make impossible any brief estimate of future exports from these countries.



Map, data 1946-48 average. Graph, latest. Because of importance of Danube Basin, Rumania, and Yugoslavia, they have been included despite lack of postwar data for these and other Danube countries.

Corn is a bit choosey as to place. Note the low yield of most Corn Belts, and different ratios between acres and bushels. *U. S. Department of Agriculture*

maintain its position. Much increase in total exports, however, will most likely depend on shipments from other areas, and Argentina remains the leading *potential* exporter, awaiting more favorable circumstances.

Three major corn-producing zones are yet to be considered, namely, Tropic America, Mediterranean lands, and Asia. In these corn is grown primarily for local human consumption. Little is exported or fed to animals. Despite its excellence for the support of human beings, corn is unappreciated as a food except in areas where people are poor. It is used there because it is cheaper than other breadstuffs. Two culinary shortcomings suffice to explain its small use: (1) it has no gluten and will not make a dough, or light bread; (2) the bread loses much of its palatability, though not of its nutrition, upon getting cold. Cornmeal gruel or mush called *polenta* is a staple article of diet for large numbers of Italians, and millions in southern Europe are poor enough to relish cold cornbread. And do not forget that *we like what we eat.*

The Spanish-American highlands. Reaching from the boundary of the United States to Argentina, the Spanish-American highlands comprise the fifth corn-growing zone. No corn is exported from these countries and little is raised for stock, since the animals usually graze the year round. In every one of them—Mexico, the six Central American countries, Colombia, Ecuador, Peru, and Bolivia—the bulk of the population, native Indians or half-breed peo-

ples, derive their nourishment to a surprising degree from corn and beans. Many of these Indians and half-breeds, known as peons, have a very low standard of consumption. The simplest shelter suffices, and rather than work much, they content themselves with beans (one of the most easily grown vegetables), corn (the cereal which they can most easily and cheaply grow), and some leaf greens to furnish bulk, vitamins, mineral salts. In Mexico and other of these countries the commonest form of corn bread is the *tortilla* or hot corn cake, which can be baked over an open fire.

In these countries the population is chiefly on the plateaus, where the topography is often broken. The corn fields are usually small, and the production, which is almost always for local consumption, resembles the family garden rather than the broad fields of the U. S. Corn Belt. Some of these plateau patches are of great fertility. It is said that there are certain fields in Ecuador where the soil, made of dust blown from the volcanos Chimborazo and Cotopaxi, has yielded crops of corn continuously for over 200 years. There is no prospect that corn will ever be grown for export from these countries. The development of their resources will follow other lines. All Mexico north of San Luis Potosí imports corn in times of peace when the mineral resources and railroads give employment to workers, in spite of the fact that the Mexican output of 100 to 150 million bushels a year is more than the combined output of all other countries within this corn-producing zone.

Among the Negro population of the West Indian islands, corn is widely used for food, but not enough is grown for home use. And here, as is sometimes the case in Yucatan, there is a relatively large import of corn and cornmeal from the United States.

Corn production in Mediterranean and adjacent regions. Most of the Mediterranean region is too dry in summer for the growth of corn except under conditions of irrigation. The large yield of corn per acre, however, makes it greatly desired as a crop by peoples poor enough to use it as their chief food. Italy, with more than 100 million bushels a year (about equal to Wisconsin), is the leader, producing nearly twice as much as Spain, Portugal, and the south of France combined. The plains of northern Portugal and northwestern Spain near the ocean have rainfall sufficient for mediocre growth of corn without irrigation, the combined output of these two countries being about equal to the crop of North Carolina. Greece and Turkey are much like Italy in the matter of corn. It is an important crop in Egypt. The 60 million bushels grown along the lower Nile are nearly all used as food.

The desert heart of the Old World and regions adjacent to it, reaching from southern Morocco across North Africa, Arabia, Iran, the deserts of Central Asia and the Gobi Desert to the Great Wall of China, can, as in Egypt, produce corn only where irrigation can be practiced. The people of the Barbary states grow some corn, as do those of Palestine and Syria. It is grown to some extent in Iran, and it is relatively important to Bukhara and other oases of Soviet Central Asia and Turkestan. In all these regions it is prized as human food.

The Corn Belts of southern and eastern Asia. The seventh corn zone is in the moist countries of southern and eastern Asia. By far the most important area is a broad belt extending from south central Manchuria across the Great Plain of the Yellow River and into the hill country of southern China. An estimated production of over 400 million bushels places China second to the United States on a national basis.[18] This area is too dry for rice, and corn is grown as a summer crop along with millet, kaoliang (sorghum), and soybeans. Although China has almost as many hogs as does the United States, corn as well as the other grains are reserved for human

[18] Estimates for 1951–52 average production are: China, 255 million bushels; Manchuria, 160 million bushels. In relation to other corn-producing zones, China-Manchuria rank behind our Corn and Cotton Belts and the Danube Basin but ahead of Argentina. Figures from USDA, *Foreign Agriculture Circular (FG 6–54)*, April 12, 1954.

consumption, as is the case in other densely populated parts of Asia.

Winter wheat often follows corn in autumn on the North China corn land. The autumn rain, needed to start the wheat is uncertain. If it fails, no wheat. If it fails two years in succession—famine, so we were told by residents at Panting, 80 miles south of Peiping.

India produces 70 to 80 million bushels of corn a year, most of the crop being grown on the alluvial soils of the middle and upper Ganges Valley. Pakistan adds an additional 15 million bushels from the irrigated lands of the Punjab. Although important in limited areas, corn occupies only about 3% of the cultivated land in India-Pakistan, and imports have been necessary in postwar years of food shortage. In Java, on the other hand, corn occupies about 15% of the cultivated area (about one fifth that of rice), and dried cornmeal is second only to rice as an Indonesian foodstuff.[19] In prewar years there was a small export from Java and a larger export of corn from Indochina to Europe. Corn is widely grown as a foodstuff in the Philippines and other wet tropical parts of Southeast Asia, where it supplements rice in the lowlands and sometimes is the main food crop in the drier or rougher lands.

2. RYE

Comparison with wheat. Rye is the world's second-class bread grain, with a production about one fourth that of the generally preferred wheat. Botanically, rye is closely allied to wheat which it resembles. It contains gluten and so will produce a "raised" bread, but the grain is smaller, less nutritious, produces less flour, and hence is cheaper. Rye's chief virtue is the fact that, under certain conditions, it will produce heavier and more dependable yields per acre than wheat. Temperature-wise, it is the hardiest of the winter grains. It can be fall-sown with assurance of good yield in areas where winter temperatures average about 0°F. and go down to 40° below.[20] As a result it is grown beyond the Arctic Circle in Europe and, in North America, the main area of production extends 300 miles north of the Winter Wheat Belt. Rye tolerates excessive moisture better than wheat, grows more successfully on thin, sandy or sour soils, and is less affected by rust and insect pests.

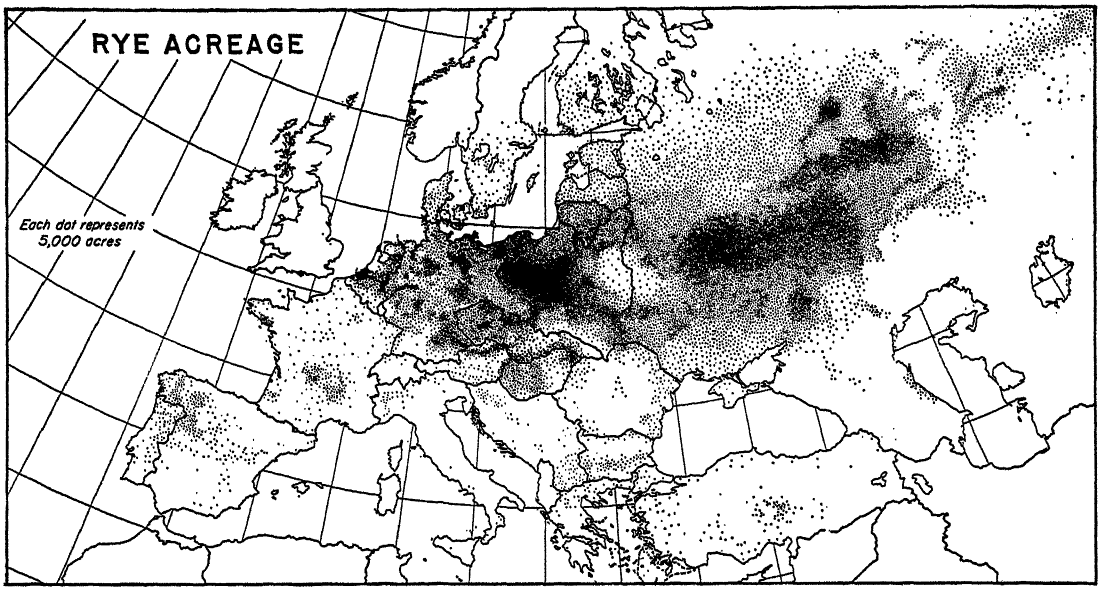
Uses. The chief use of rye is as a breadstuff, primarily for people with a low purchasing power and consequent less-expensive standard of consumption. For example, in Central, North, and northeastern Europe rye is the chief breadstuff of the poor, as Indian corn, the cheap grain of the warm land, is in parts of South Europe, the Danube Valley, and Mexico. In recent years there has been an increasing use of rye for feed, especially in Central Europe. But animals, like humans, seem to prefer other grains. In addition, rye is a soil-conditioning crop and is sometimes plowed under for green manuring.

Regions of production. The region of the world's greatest rye production is in the low plain of North Europe, reaching from the Low Countries along the English Channel through Germany and Poland and on into Russia and beyond the Ural Mountains. This is mostly the region of "small grain, potatoes, grass" climate with moist, cool summers and winters increasingly cold toward the interior and the north. (See colored map.) Owing to the work of glaciers, which once covered this part of Europe, the soil is in many places sandy and poor. Here rye grows better than wheat and without it there would be many fewer people in this relatively densely populated area. Europe and Russia produce about 95% of the world's rye, with Russia contributing a half, and Poland and Germany together nearly a third (see Fig. 118).

The peasants and factory workers of rye-growing countries eat the most of it in the form of black bread, which, after all, is nearly as nourishing as wheat bread, and more nour-

[19] John E. Metcalf, "The Agricultural Economy of Indonesia," USDA, *Agricultural Monograph No. 15,* 1952, pp. 38, 45–46.

[20] Leo J. Schaben, "Rye—A Source of Daily Bread," *Foreign Agriculture,* August 1948, pp. 163–168.



Black rye bread has been the backbone of the diet of the majority of the people of Central and North Europe for many centuries. ***U. S. Department of Agriculture***

ishing than much of the white bread eaten in America. But these people frequently substitute the esteemed wheat bread for rye bread, when they become able to buy wheat.[21] It has been reported that the base of the German army ration in World War II was black bread and soybeans.

As it grows with little care and on rough ground, rye was an important crop to the early settlers in the northeastern United States, but after the opening up of the fertile level West, it was neglected in favor of wheat. During the last 25 years rye growing in this country has fluctuated greatly, and since prewar years has declined about half. Our 1950–52 average production of 19 million bushels was under 2% of world production and equally small in comparison to our own wheat crop. While rye has held its own in the poorer lands of the east, the main area of production is along the eastern and northern margins of the Spring Wheat Belt (see Fig. 76). Here it spreads farm activity by providing a fall-sown crop which can be harvested before wheat is ready. From the standpoint of crop rotations and farm practice, (including mechanization), rye, oats, and barley are similar to wheat but call for planting and harvesting at slightly different times.

Canada and Argentina are the only other significant producers outside of Europe. Together with Russia they are the leading exporters of the very small amount of rye that moves in world trade.

3. FLAX

Flax is a grain, a fiber, and the source of an important vegetable oil. Flax fiber is produced chiefly in Europe, in many areas where rye is also important (see Section 2). But seed flax, planted, harvested, and handled in every respect like wheat, is a grain, grown in several of the important wheat regions, chiefly in Argentina, Russia, the Spring Wheat Belt in the United States and Canada, and northern India. Flaxseed is crushed to produce linseed oil, an important industrial oil used in the manufacture of paint and varnish, although in some areas, such as India, it is also consumed as food. The oil-seed cake that remains is high-

[21] The operation of this preference is indicated by the fact that world rye production declined from 1.8 billion bushels a year in the years 1900–05 to 1.6 billion bushels in 1952–54. Comparing the same periods, world wheat production increased from 3.5 to 7.1 billion bushels.

ly prized as stock feed in the producing countries and is also exported to Europe.

In the United States flax was an important frontier crop as agricultural settlement spread through the Middle West. The plant requires rain during the spring and early summer and is tolerant both of cool weather and a variety of soils. Production is therefore favored in the Spring Wheat Belt where Minnesota and North Dakota together produce about three fourths of our 40-million-bushel crop (1954).

World production has remained at the prewar level of about 130 million bushels, but important changes have taken place among the producing countries. Production in the United States has quadrupled, while that of Argentina has dropped to about 40% of the prewar level. These two countries each contribute about a quarter, with India and the Soviet Union producing about 10% each of the world total.[22] Export patterns have also changed with the decline in the surplus available from Argentina, together with the tendency for exporting countries to process their flaxseed and ship linseed oil and oil cake. Europe remains the major important market for all three products: flaxseed, linseed oil, and cake.

4. OATS

Oats are virtually a Northern Hemisphere crop, with production about equally divided between the Old and the New worlds, in striking contrast to the European dominance of rye. In its climatic requirements the crop is broadly similar to wheat, but being nearly always spring-sown, it has a later growing season and requires more rain. Consequently, oats do not do so well as wheat in areas of hot, dry summer[23] but are more productive than wheat in cool, damp climates. Oats are also tolerant of a broader range of soils than either wheat or barley. Because of these qualities the crop is grown to some extent in nearly all the important wheat regions and also in the rye and northern barley regions. In general, the areas of heaviest oats production lie northward of the major wheat areas in Eurasia, and north and east of the wheat belts of North America.

The crop is of the greatest relative importance in such cold, damp countries as Eire, Scotland, Sweden, and Norway, and is grown to a great extent also by the people of the central and eastern European rye belt. It is also important throughout Canada, where the climate is too cold for corn. In the colder northern parts of Korea and Japan, where rice does not thrive and wheat is not at its best, the farmer resorts to oats and barley.

Uses of oats. The Scots, probably because of their moist climate, have most largely utilized the oat as human food. Dr. Johnson's famous English dictionary is said to have defined oats as "food for men in Scotland, horses in England," to which the unbeatable Scots replied, "And England is noted for the excellence of her horses, Scotland for the excellence of her men." The farm laborers of Scotland are said to have almost lived on oatmeal and milk in some areas and at some periods. The people of other countries are now, since the coming of the breakfast-food habit, learning to eat more oatmeal. A little oaten bread is used in parts of North Europe, but the main use is as horsefeed, mostly as grain but increasingly as hay. Oats are seldom raised as a cash crop and are usually fed on the farm where grown.

Grown on same farm as corn. The fact that oats are better adapted to corn-farming crop rotation than any other small grain makes them very important in the Corn Belt of the United States. In much of this territory the summer is not fully suited to spring-sown

[22] Figures are for the 1945–49 average. Later figures for the U. S. S. R. are not available. Argentina's production has continued at a low level, with Canada pressing for fourth place. USDA, *Agricultural Statistics, 1953,* p. 125.

[23] Fall-sown or early maturing spring-sown varieties, which ripen before the summer drought, are grown to some extent in regions of Mediterranean climate or the subhumid grasslands of the continental interiors, such as our southern Great Plains. However, production in such areas is relatively unimportant. See K. W. H. Klages, *Ecological Crop Geography,* The Macmillan Co., New York, 1942, pp. 373–375.

wheat, and the alternate freezing and thawing of the open winter often injure winter wheat. Oats, not being hurt by a little frost, fit nicely into these climatic and agricultural conditions by being sown very early in the spring before corn can be planted. Since it is not necessary to plow the seed bed, where oats follow corn, this crop permits great economy of labor. After seeding they require no attention until harvest time, which does not occur until after the corn has been planted and has received its cultivation. Then while the corn is maturing, after the hay harvest or possibly before it, the oats are harvested. The excellent way in which these crops dovetail together makes the field of oats as well as the field of corn and the field of hay a part of the great Corn Belt farm system, and here is grown the greater part of the United States crop, which in 1952–54 averaged about 1.3 billion bushels. By number of bushels this places oats slightly above wheat and second to corn. In tonnage, however, the average wheat crop weighs nearly twice as much as the oat crop.

Europe and Russia still produce slightly more than the United States and Canada, with the main producing area corresponding roughly with that for rye. As in our Corn Belt, oats fit well into the European system of crop rotation and are even more important as a feed crop in an area virtually without corn. Some of the decline in European oats production is owing to the substitution of barley as a feed crop since barley gives higher yields on better soil, but oats still produce more feed on the sandy soils common in this part of Europe.[24]

Effect of light weight on export. The oat grain has a thick, light, close-fitting husk which is not removed by ordinary threshing. It is left upon the grain if used for animals and only removed by special machinery when the grain is prepared for human food. The large bulk per unit of value (a bushel of oats weighs only 32 pounds) is one of the reasons for the small export, which in the United States amounts to less than a twentieth part of the crop. Another and greater reason for the small export from America is the great importance of oats in the agriculture of the grain-importing countries of western and northern Europe.

Oatmeal makes up an important part of the American export of oats, the centers of manufacture being in a number of small towns in Iowa and other Corn Belt states, from which the familiar little pasteboard boxes go out in millions, while the more economical sacks and barrels also take their share.

5. BARLEY

Hardiness, range, and uses. "Wheat has the distinction of being the prime bread crop of the world, rye . . . of being the most winter-hardy of the cereals, while barley is outstanding from the standpoint of being able to mature in a shorter season than any other cereal crop."[25] Barley can mature in a period of only 90 to 100 days, so that it can be grown in areas where the season of growth is cut short either by low temperatures or by lack of moisture. It can also withstand a good deal of heat. Consequently, it is grown under more extreme environmental conditions than any other important cereal. It is important in northern Scandinavia and Russia, growing beneath the midnight sun and ripening 150 miles beyond the Arctic Circle in 70°N. Lat. It is grown in the high mountains the world over and provides food for the inhabitants of the Tibetan Plateau at elevations of over 10,000 feet. It requires less moisture than either wheat or oats, largely owing to its short growing season, so it penetrates farther into dry areas, both tropic and midlatitude. This versatility is due, in considerable measure, to barley's long history as a cultivated plant, which has resulted in the development of a great number of varieties

[24] *Ibid.*, p. 375. Estimated annual average production of oats, in millions of bushels, USDA data:

	1935–39	1953–54
United States	1,045	1,368
Canada	338	436
Europe	1,608	1,399
U. S. S. R.	1,165	750[a]
All others	209	324
World	4,365	4,277

[a] 1950.

[25] Klages, *op. cit.*, p. 363.

adapted to contrasting environmental conditions in various parts of the world.[26]

Barley was a major food source in numerous ancient civilizations as well as in medieval Europe. It is still used as a foodstuff in many parts of Europe, in high-altitude areas of Eurasia and South America, as well as in densely populated Oriental countries.[27] However, its use in countries with higher standards of consumption is chiefly confined to stock feed and the making of malt for beer. About half of the 250–300-million-bushel crop in the United States is fed to livestock, a third is used in producing malt, and the rest for seed and export. Not only does barley grow under extreme environmental conditions, but it also produces heavy yields on good soils in areas of moderate climate. Therefore, it serves as a feed substitute for corn in countries that cannot grow sufficient corn, such as Canada where acreage has tripled since World War I, also in Europe north of the Alps, and on the Pacific slope of the United States.

Barley-producing areas. Barley's short growing season and its tolerance for slightly alkaline soils make it important in the drier lands with a short rainy season, such as those around the Mediterranean Sea, Asia Minor, Central Asia, Australia, and California, where it will grow closer to the deserts than wheat. Barley has been grown in California since the Gold Rush days, and the crop is now four times as large as the wheat crop. In the Great valley barley produces a larger average return per acre than either wheat or oats. High-grade malting barley is grown in the Sacramento Valley, but most of the California crop is used as corn is in Iowa—for horse, cattle, or hog feed. Here, as in Australia, the crop is sometimes cut for hay just before the grain is mature. At this time the entire plant makes excellent forage.

The most important barley region in America reaches from Chicago northwestward through Minneapolis up into Canada, and corresponds roughly with the Spring Wheat Belt, but also laps over into the Dairy and Corn belts. Although there have been important shifts in acreage within this area, it has maintained its national dominance for over 60 years.[28] The fact that barley ripens earlier than wheat is a factor of very great importance because the two crops, one food for man, the other feed for beast, do not compete for the grower's time at harvest, so that he can grow more acres of the two grains than he could of either alone. The superiority of corn as a forage plant in the United States has limited the growth of barley in this country (see p. 108).

If we should some day have a new sense of patriotism and realize that a gullied corn field is a partial destruction of the United States—then our barley crops will boom. A dairy farmer in Virginia (39°N. Lat., alt. 500 ft.) harvests annually from the same field a barley crop in June and a soybean crop in September, and does it year after year.[29]

In Europe barley spans the continent from Mediterranean to Arctic, from Atlantic to the Urals. However, the major production is in the intensive agricultural areas where it takes a place in the farm economy similar to that of corn in the American Corn Belt. Little Denmark with her many cattle grows about 6 times as much barley as wheat, while in Germany and Great Britain it occupies nearly as much acreage as does wheat. Barley, with its high yield per acre, fits well into a rotation with

---

[26] Grains of barley found in Egyptian sites of Neolithic culture dated 5000–6000 B.C. are identical to contemporary barley growing along the desert margins in North Africa and Southwest Asia. For an interesting discussion of the antiquity and varietal ecology of this historic grain, see John C. Weaver, *American Barley Production, A Study in Agricultural Geography*, Burgess Publishing Co., Minneapolis, 1950, pp. 1–6; citation on p. 3.

[27] The Japanese produce it on lands not suited for rice and also as a winter crop on rice land. Production is about one seventh as great as the rice crop and about 50% greater than the wheat crop.

[28] Weaver, *op. cit.*, provides a detailed description and analysis of factors influencing the geography of barley production in the United States since 1839.

[29] Within the past two decades, development of new varieties of winter barley suitable for eastern and southern states from Pennsylvania to Texas has resulted in some expansion of acreage and holds promise for much agricultural betterment in these areas. *Ibid.*, p. 52.

sugar beets on the better soils of Germany, Poland, and Russia. In the years 1952–54 Europe produced an average of 810 million bushels. With Soviet production (estimated at 325 million bushels in 1950), this would amount to about 40% of the world crop. Another 30% comes from Asia, with North America, Africa, and South America following in order.

6. MILLET AND SORGHUM

Millets and sorghums are ancient cereals,[30] relatively new in the Americas but of major importance in the Old World. They are the most truly drought resistant of our cereals. They can grow on poor soils, under high temperatures, and with little rainfall. In the New World they are used primarily as feed and fodder crops. They are similarly used in the Old World, but more important is their utilization for human food in the drier parts of Monsoon Asia, Africa, and Russia. Asia accounts for nearly 70% and Africa for a quarter of the estimated world acreage—185 million, Russia excluded.[31] On this basis, the acreage of sorghum and millet together is exceeded only by that of wheat, rice, and corn among the world's cereals.

Millet is a plant not unlike corn or sugar cane in general appearance, with its seed in a head somewhat like that of the cattail. In the Far East the grain, which is smaller than wheat grains, is boiled and used like rice, eaten parched, or made into meal and porridge. There are many varieties, some a dozen feet in height. Some are grown for forage only, some for the grain to be used as human food, some for both purposes; some varieties furnish fuel in their woody stalks. It is claimed that Chinese soldiers have marched 100 miles a day with millet as chief food—a Chinese claim.

Millet requires moderate amounts of moisture during the early period of growth but can mature and ripen under virtual drought conditions. Certain varieties require a growing season of only 60 to 90 days. These characteristics fit the plant to warm, subhumid and semiarid areas with seasonal rainfall. The early maturing varieties can even be planted as a catch crop after the failure of other crops. Millet is an important, sometimes the main, source of food for millions in China and India, and to a lesser extent in Russia and parts of southeastern Europe. It produces well under primitive methods of cultivation, which is a further reason explaining its importance in Africa. About 85% of the world production is used as food.[32]

Sorghum is much like millet in general appearance and the two are often confused both in the field and in the literature. It is quite similar to corn in its growth habits, but can withstand periods of drought during its growing season much better than can corn. Sorghums are "the most drought-resistant of field crops."[33]

In India-Pakistan, which has about half the world's acreage in both sorghums and millet,

---

[30] Millet was important to the Stone Age lake dwellers in Switzerland and is mentioned in Chinese records of 2700 B.C. Sorghum was cultivated in ancient Egypt and is supposed to have come thence from India.

[31] Statistics for these crops are unreliable, owing to confusion between sorghum and millet, and the importance of production in areas where reporting methods are, to say the least, primitive. The following estimates indicate the general world pattern. Data from U. N. Food and Agricultural Organization *Yearbook of Food and Agricultural Statistics*, 1952, Part I, pp. 38–40.

Millet and Grain Sorghum, 1950–52 Average
(millions of acres)

	Millet	Sorghum
North America	.2	9.6
South America	.4	...
Europe[a]	.3	.1
Asia	68.8	60.3
Africa[b]	23.3	12.5
Oceania	...	.2
World total[b]	93.0	82.7

a Excluding Russia, which had an estimated 13 million acres of millet in 1939.

b There was an additional 9.3 million acres unspecified (sorghum *or* millet), mostly in Africa. This makes the world total of 185 million acres.

[32] See Elna Anderson, "Millet Provides Food for millions," *Foreign Agriculture*, November 1948, pp. 235–239.

[33] Klages, *op. cit.*, pp. 204–206, 406–407. Klages explains that sorghums can remain virtually quiescent during periods of unfavorable weather and are thus "the only field crop approaching the true xerophytes."

the two crops are grown in the same general area—especially in the Deccan Plateau and the drier areas to the northwest. Sorghum tends to be grown on the better soils and the more humid sections. The combined area of the two crops in India-Pakistan is almost equal to that of rice and nearly three times the wheat acreage. In North China and Manchuria, sorghum (here called kaoliang) is also a major crop. In the Yellow River Plain, wheat, kaoliang, and millet are the major food crops. Farther west, in the drier hill lands of Shansi and Shensi provinces, sorghum gives way to millet, another example of the areal relationship between these two crops.

In the United States, millet is relatively unimportant. A little is grown in many parts of the country for forage, but it has been virtually replaced for this purpose by sudan grass, one of the sorghum family, which has been widely accepted since its introduction some 40 years ago. A little millet is grown for grain in the northern Great Plains states, sometimes as a catch crop.

Sorghum, by contrast, has expanded rapidly, especially during the drought years of the 1930's when acreage rose from 8 to 18 million acres and has ranged from 11 to 20 million since then. The major centers of production are in the western portion of the Winter Wheat Belt in Texas, Oklahoma, and Kansas, but sorghum is also grown eastward into the Corn Belt. About half the acreage is harvested for grain and the rest for fodder and silage. Sorghum is proving itself a valuable secondary crop, giving added stability to agriculture in this area of high temperatures and variable rainfall (see p. 108).

7. BUCKWHEAT

Buckwheat, an unimportant cereal, is among the grains as the goat is among the animals—conspicuous for its ability to nourish itself where the supply of nourishment is meager. This feeding habit of the plant, enabling it to live in the poorer and rougher lands, in combination with its very short period of growing makes it the cereal best fitted for growth under the worst conditions of cold countries. These characteristics also make it a soil exhauster. It grows so quickly that it can be sown in midsummer in eastern United States after other crops have failed, or have been harvested, and yet ripen before frost. Its qualities combine to make it a crop for farms of rough and mountainous localities, such as the upper part of the Appalachian Plateau in New York and Pennsylvania, parts of New England and Canada, the mountainous districts of France, the Alps, and Russia. The excellence of the buckwheat flour for making batter cakes makes it a favorite article of diet where buckwheat is known. Persons who keep bees for the large-scale production of honey sometimes grow buckwheat because of the large amount of honey in the flowers, thus getting a double harvest. New York and Pennsylvania produce about two thirds of the total crop of the United States, which amounts to less than 1% of the wheat crop.

8· The Vegetable Industries

1. VEGETABLE PRODUCTION AND TRADE

Vegetables and garden products. Nearly every farm has a vegetable garden and vegetables are grown in nearly every climate region. They are produced in gardens and greenhouses beyond the Arctic Circle and in the clearings of the Tropic Forest. They are grown under irrigation in dry regions, by the Oriental peasant in Monsoon Asia, and by the farmers of humid Europe and the Americas. Large amounts of vegetables can be produced on a small area of land. Consequently, intensive care is devoted to vegetable production, whether it be on a commercial truck farm, the family garden of farm or village resident, or the "victory" garden of the city-dweller, turned part-time farmer in the face of wartime food shortages.

The commercial truck gardens of Europe and America contain a large variety of plants that represent in their origin every continent and almost every country in the world. In many cases they have been cultivated until they bear little resemblance to their original form, and in our list of vegetables is found in edible form every part of a plant—roots, stems, leaf stalks, leaves, blossoms, pods, seeds, fruit.

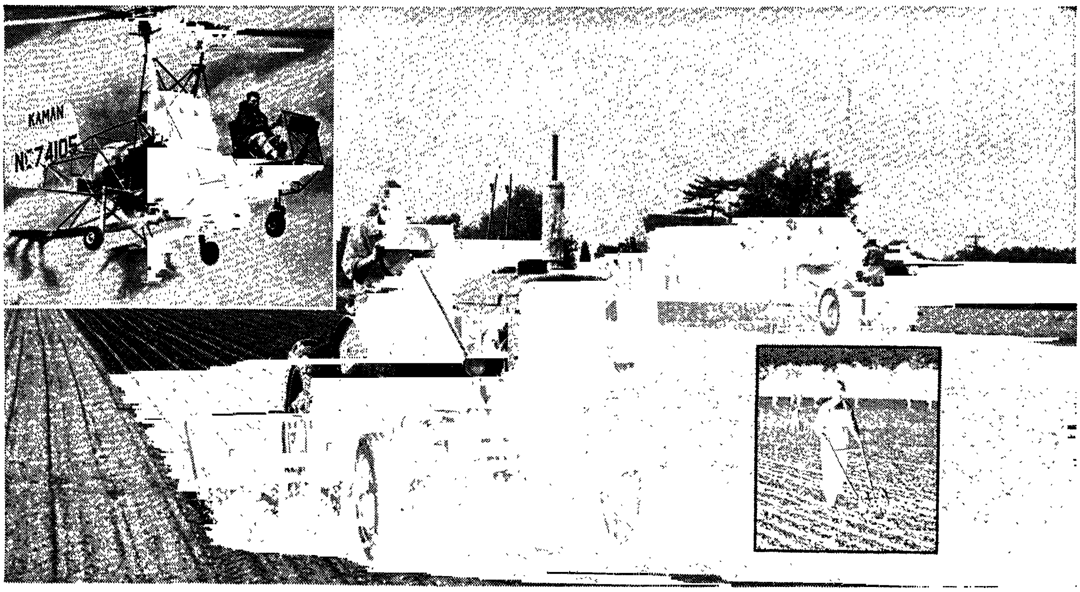
The commerce in vegetables. Although most of the world's supply of fresh vegetables is still produced near the market,[1] the development of refrigeration and cheap, high-speed transportation has greatly increased the volume and radius of trade in these bulky and perishable foods. The perfection and increased use of the refrigerator ship, the refrigerated railway car and motor truck, and terminal storage facilities with scientific automatic temperature control now permit the continuous sale of fresh vegetables and fruits in the urban markets of Europe and America, with many shipments moving hundreds or even thousands of miles.

For some years the diet of America and, to a lesser extent, western Europe has been shifting somewhat from a bread, meat, and potato basis to one of cereals, fruits, and vegetables. We ride in automobiles, busses, and subways. We push buttons and pull levers. We save energy and need less food. Each year our per-capita consumption of fresh vegetables, rich in minerals and vitamins, continues to increase.[2]

Vegetable production in the United States. The map of vegetable acreage (Fig. 127 left) reveals the importance of the northeastern quarter of our country. Here are both the major urban markets and localities favor-

[1] Although statistics on a world basis are lacking, it is probable that the great bulk of world vegetable production is consumed by the producers themselves. Even in the United States the value of vegetables grown for home use is about four fifths as great as that of vegetables produced for sale.

[2] Between 1909 and 1952 the per-capita consumption of fresh vegetables (excluding those grown for home use) increased from 100 to 142 lbs. On the other hand, the per-capita consumption of white potatoes (not counted as a "fresh" vegetable), a great starch food that adds to milady's corpulence, has decreased from 184 to 101 lbs. USDA, *Agricultural Statistics, 1952,* pp. 320–321.



Intensive hand agriculture? This cultivator is hoeing 8 rows of spinach and going faster than the man with the wheel hoe on the level sandy loam of New Jersey Coastal Plain. At harvest, a mechanical cutter will scoop the spinach into a truck, and in 2 hours it will be in packages, 40° below zero. *Seabrook Farms*

The helicopter duster, working in Colorado, boasts that he can go into narrow valleys. *Rocky Mountain Aviation.* Seabrook dusts with wing planes, and tractor has replaced the wheel hoe.

able for the production of most vegetable crops, especially sweet corn, tomatoes, peas, and beans. The southern states, particularly Florida and Texas, together with California, produce for their own growing cities and, as a result of their milder climate, ship large quantities of special and off-season vegetables to the north and east. In most areas of production there are processing plants which dry, can, or freeze vegetables. About half the total crop is processed before moving to market in these less-perishable forms.

The economic geography of vegetable production is therefore a complex of many different vegetables, often grown in different areas as the season advances, sometimes on large "factory farms," sometimes on small one-family holdings, and moving to market in various forms.

Truck farming on the Atlantic Plain. Our Atlantic Plain is a nearly level area lying between the Atlantic Ocean and the first stratum of hard rock that limits the sands and clays on the west. The sandy soils of this plain are not naturally fertile, and much of it remains covered by second- or third-growth pine forests. Fortunately, however, this soil can be made highly productive through the application of fertilizer. It is good for the growth of peas, melons, cabbages, strawberries, etc., which are composed very largely of water, and which have a much earlier planting and harvest time on light sandy soil than on heavy clay soil, which does not dry or warm so quickly as sand. Thus the Atlantic Plain has a seasonal advantage over the Piedmont and Appalachian districts lying to the west, with their fertile but heavy clays.

From this sandy Atlantic Plain stretching from Florida to Long Island, there comes a procession of vegetable products that follows the advance of the seasons. When October's breath of winter turns the fields of New Jersey and Long Island brown, the huckster and the groceryman of the northern city begin to sell beans, lettuce, eggplants, and cucumbers from southern sands, and at Christmas come Florida strawberries which New Jersey can produce only in May and June. The Florida truck farmer often has a rapid rotation of crops.

A skilled farmer ships heads of lettuce in January; the ground is immediately set to tomato plants from which the crop is shipped in March; then potatoes are planted for shipment in May; while, through the summer, the velvet bean, a rapidly growing legume of the tropics, makes food for his mules and leaves nitrogen in the soil for the crops of the succeeding winter.

As the spring advances northward so does the location of the truck harvest. Next after the supplies of south Florida come those of north Florida, to be followed in turn by shipments from Georgia, the Carolinas, and southern Virginia. The peninsula between the Chesapeake Bay and the sea, known as the "Eastern Shore," is one of the finest agricultural districts in the United States with a climate modified by the adjacent water bodies and an excellent system of rail and highway transportation. In early June potatoes are grown here and sold by an efficient cooperative association in many parts of the U. S. and Canada, and large amounts of other vegetables move to the fresh markets and processing plants as the summer advances. Lastly come the heavy shipments of truck crops from the fields of southern and eastern New Jersey, Long Island, and the smaller areas near the New England manufacturing cities.

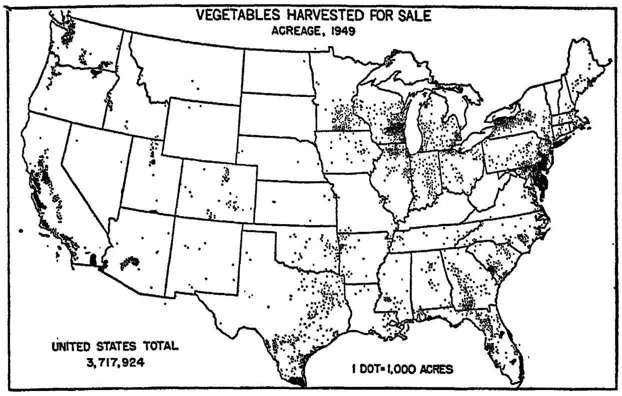
Other eastern areas. In our eastern states vegetables are by no means restricted to the Atlantic Plain. Fertile soil areas in southern New England, New York, and southeastern Pennsylvania produce large quantities of most of the leading vegetable crops. Like the northern part of the Atlantic Plain, these areas are close enough to the big city markets to give their producers a distinct advantage over more distant localities during their season of production. This is one reason explaining the growing importance of the motor truck in the transportation of these bulky and perishable goods.[3]

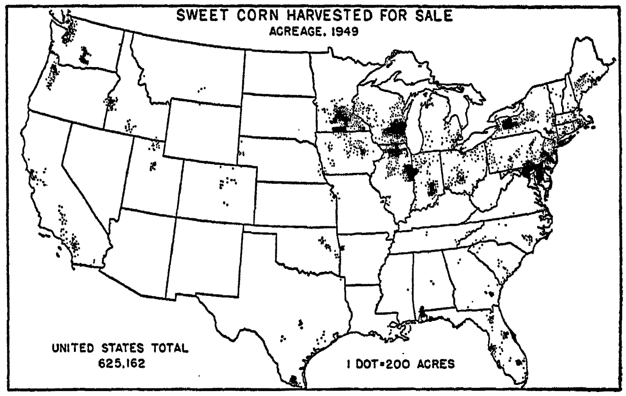
A business with the gambler's chance. The price of the vegetables varies from season to season, indicating that the business is uncertain and, as shown by the extent of the variation, a perilous one. The earliest products on the market bring the best returns. So the truck grower always aims to be as early as he can, and therefore is in constant danger from the frost, of which the cold waves always hold possible store. A promising harvest may be blackened by frost in a single night or spotted by fungus encouraged by one or two muggy days, or a severe January freeze may cost Florida millions of dollars. Rains and cool weather in one section at times retard the development of the plants, causing the product of two or three great centers to mature at one time and produce more than the market demands, so that the price goes down to the point where the shipments will not pay the freight. This is even more common than frost. Indeed it is this lack of profits—this loss because of oversupplied markets—that checks the development of the industry. The coast plain has many times as much land as is needed for truck, and the ever-recurring losses stop the indefinite expansion of the industry.

The vegetable industry of the Mississippi Valley. About one quarter of our acreage in truck crops is in the six states bordering the Great Lakes from Minnesota to Ohio. The cities provide a ready market for fresh vegetables, while fertile soils, good climate, and an intensive agriculture result in large production for processing. For example, Minnesota is usually the leading state for sweet corn, Wisconsin for peas and second (or first) for corn, while Michigan leads in cucumbers—all these crops are grown more for processing than as fresh vegetables.

Like the urban centers in the East, the cities

[3] A recent study of transportation of 10 selected fresh vegetables and fruits to 8 major cities revealed that the proportion carried by truck, as well as the average length of haul, increased slightly between 1941 and 1950. In 1950 the average length of truck haul to these markets was 325 miles, and trucks handled 49% of the goods covered by the study. Trucks dominated the shorter hauls, handling over 80% of all shipments moving less than 500 miles but only 10% of those moving more than 1000 miles. Margaret R. Purcell, *Length of Haul to Leading Markets by Motortruck 1941 and 1950, selected Fruits and Vegetables,* USDA, Bureau of Agricultural Economics, June 1953, pp. 2–3.





Note value of dots. Thirty different vegetables combine to use only 1% of our crop area, but produce nearly 5% of the total value of farm crops. Most vegetables west of the 100th meridian are irrigated. Six crops account for nearly two thirds of the total acreage. In rank: corn, tomato, watermelon, green peas, snap beans, lettuce. The sweet-corn map illustrates well the tendency for individual garden crops to develop localized areas of production. This has many advantages, both for growing and marketing. About two thirds of the corn crop is canned, but in California, the South, and around urban centers most of it is marketed fresh. *U. S. Bureau of the Census*

in the central part of our country draw off-season supplies from the South and the West—partly from certain sandy districts in Tennessee, Mississippi, Louisiana, northwestern Texas and from the irrigated lands of the Lower Rio Grande Valley of Texas. The parade of south Texas vegetables to northern markets occurs in well-defined seasons. Early potatoes are shipped to market from December to March, cabbages in February, March, and April, and tomatoes in May and June. More than 50 different crops are grown in this valley alone, which normally ships about 25,000 carlots of fresh vegetables each year, mostly to northern markets, of which one fifth move by truck. Within the valley are distinct centers of specialization, Crystal City, Tex., claiming to be the largest spinach-producing center in the world, with a monument—a bronze monument, if you please—to a hero named Popeye. It stands in Popeye Park.

The California vegetable industry. California, with its mild winter and large-scale irrigation, is by far our leading state in vegetable production.[4] The rapid growth of west-coast cities provides an expanding market, and Los Angeles is second only to New York City in receipts of vegetables. In addition, low production costs and seasonal advantages counteract the high transportation charges and allow long distance shipments to markets east of the Mississippi. Truck crops are found in most of the state's agricultural sections, but certain areas are especially important. The muck soils of the reclaimed delta lands ("tules") at the mouths of the San Joaquin and Sacramento rivers are fine for the production of asparagus and celery. Tomatoes are grown on the lighter soils of the Sacramento Valley and elsewhere in the state. Various vegetables are produced in the smaller valleys of the Coast Range south of San Francisco, of which the Salinas Valley with its lettuce is the best known. The Los Angeles Basin is important for truck as well as for fruits, while in the extreme south the Imperial Valley specializes in vegetables—melons, lettuce, cabbage, and peas. Partly as a result of marketing and shipping problems, large-scale farming is more prevalent in California than in the eastern truck district.[5]

[4] In 1952 California had 601,750 acres in truck crops, of which 399,550 produced vegetables for the fresh market. Wisconsin, in fourth place, had 297,900 acres but only 10,600 of these produced vegetables for the fresh market. Why? USDA, *Agricultural Statistics, 1953,* p. 222.

[5] A "medium-sized" grower-shipper in the Salinas Valley operates 1200 acres of truck land with an ice plant and packing house, generally shipping 750 (rail) cars of lettuce, 100 cars of carrots, 150–200 cars of celery, and 100 cars of broccoli or cauliflower each year. J. D. Black, *et al., Farm Management,* The Macmillan Co., New York, 1947, p. 896.

Other western areas. In recent years southern California has encountered increasing competition from other sections of the West. For example, lettuce is produced and shipped in large quantities to the East from the White River Valley of Washington, the irrigated lands of the Salt River Valley of Arizona, as well as from the Salinas Valley of California. The high mountain valleys of Colorado and New Mexico ship midsummer lettuce which thrives in the coolness of elevation.

American foreign trade in vegetables. External trade in vegetables is relatively unimportant in view of our large domestic market and huge and varied production. Imports are of two types: seed potatoes from Canada, and early season vegetables from our neighbors to the south with their warm climate and cheap labor. Most of the latter, chiefly tomatoes, green peppers, and peas, come from the vicinity of Havana in Cuba and from irrigated districts in Mexico's lower California. Some onions are imported from as far away as Italy and Chile. Exports, which amount to only 2% or 3% of our fresh-market consumption, go mostly to Canadian cities close to our northeastern border. Much more important, both in quantity and value, are exports of canned vegetables. Countries of the Western Hemisphere have been our main customers, although, since World War II, there have been increased but fluctuating shipments to more distant markets.

Vegetable production and trade in Europe. Western Europe, with an acreage in commercial vegetables about equal to our own, produces about a third more on a tonnage basis. Like the United States, a great variety of vegetables is produced, but the most important, amounting to about 50% of the total production, are cabbage, tomatoes, green peas, beans, cauliflower, and onions. Note the absence of sweet corn, watermelons, and lettuce —among the leaders in the American list. Another contrast with the United States is that there is less long-distance transport. Production for home use is probably more important, and most of the commercial vegetables are marketed within the producing countries, only about 5% moving across international boundaries.[6]

The industrial countries around the English Channel are major producers as well as the chief import market. Here also is the leading exporter—the Netherlands, where the industrious Dutch carefully till their sandy soils as well as their heavy-textured drained lands and export about one third of their commercial vegetable produce to urban markets in nearby countries.

Southern Europe enjoys the advantages of a "California" climate, and, like California, Italy and Spain ship off-season vegetables to urban markets across the mountains. Other Mediterranean countries in North Africa and the Near East contribute to this trade. France, for example, imports vegetables from its North African territories and also exports its own produce, largely to England and West Germany.

2. PEAS AND BEANS (PULSE)

The nitrogen-producing legumes or pulse. The most important of all vegetables is the group of legumes comprising the many kinds of peas and beans, which are called pulse in the Old World. These differ from all other vegetables in the large amount of protein or nitrogenous food, meat substitutes, which they contain. Nitrogen, as food for man, beast, or plant, is expensive to buy, yet over three

[6] Commercial Vegetable Production and Trade, Selected West European Countries, 1951 (thousands of metric tons)

	Production[a]	Exports	Imports
United Kingdom ..	3,044	...	490
Germany, West ...	1,357	...	296
France	4,700	97	160
Belgium-Lux.	509	41	55
Netherlands	1,021	352	8
Italy	3,556	238	...
Spain	3,411	210	...
Total above	17,598	938	1,009

Total 16 countries, 20,906.

a Crop-year 1950–51.

Source: U. N. Food and Agricultural Organization, *Commodity Series, Bulletin: No. 23,* "Fruit and Vegetables, Production, Trade, and Policies in Europe, 1947–1951," Rome, October 1952, pp. 13, 14, 33.

fourths of the air is nitrogen, which, owing to its chemical inertness, is hard to obtain in available forms. Hence its high cost. The legumes have the ability, great for the present, still greater for the future, of producing upon their roots nodules which are colonies of the microscopic plants called bacteria. These organisms catch nitrogen freely from the air and thus enable the legumes upon which they live to render to mankind a service of incalculable value by giving nitrogenous food for man, beast, or plant. (See Fig. 474.)

By the aid of these bacteria the legumes can grow in poor soil and leave it the richer in nitrogen because of the nodules on the roots that remain in the ground. Experiments have even shown that nonlegumes growing beside living legumes are richer in nitrogen content than similar plants not so placed. Sometimes these leguminous crops are not harvested but are plowed under to enrich the soil.

The pulse plants are represented chiefly by peas and beans. World acreage is estimated to be at least 100 million,[7] a figure in the same range as the totals for rye, barley, or oats. However, the higher yield and special food values of the pulse family probably make it more important to the world's food supply than any of these "minor" grains. Peas are grown largely in the relatively cool parts of the temperate zone, but beans are produced under diverse climatic conditions, much of the world's bean export trade originating in tropical and subtropical lands. Peas and beans are less used for food in the United States than in any other large country, because Americans get their nitrogenous food in the more expensive forms of meat, cheese, and milk. However, they are increasingly important for animal feed and soil improvement, and, since World War II, the United States has been the world's leading exporter of edible dry beans, and peas.

Importance of pulse to poor peoples. In the Mediterranean countries the pulse plants are much more important than among the wealthier peoples of North Europe. The lower wages of the Spaniards and Italians make it difficult for them to buy meat from abroad, as do the British, and the dense population, combined with the lack of grass, make impossible the rearing of adequate numbers of meat animals per capita. To get their nitrogenous food the Spaniards, Italians, and other people of the Mediterranean turn therefore to the cheaper forms of peas and beans. The chick-pea, or garbanzo, is one of the chief items of diet in Spain and is also greatly used by the peoples of Morocco, Algeria, and Tunis, whence it is carried by caravans into the desert in exchange for dates.

With pulse, as with other staples of food, the western European supply is insufficient. Spain imports them from Mexico; England imports them especially for making soup; while France gets thousands of tons per year from northern India. Lentils, vetch, and lupine, other pod-bearing pulse plants, somewhat like our peas and beans, are much grown throughout all Mediterranean countries.

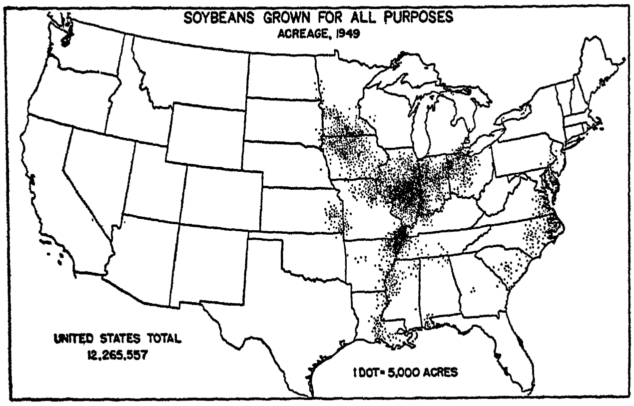
In the even more crowded and poverty-stricken areas of eastern and southern Asia, foods of the pulse family are an absolutely indispensable article of diet. Rice, substitute for potatoes, is deficient in nitrogen, but peas and beans supply this need, and these countries lead the world in their production. India and Pakistan have about 90% of the reported world acreage in chick-peas and 60% of the total in lentils, while estimates for China make it the leading producer of dry peas and beans.

The soybean. In Manchuria, China, and Japan, however, the chief dependence is the soybean—the world's most important and versatile legume and the one with the most fluid geography. It is a summer crop, a remarkable

[7] Some countries do not collect these statistics, others withhold them. The following are therefore minimum estimates for 1952, with important producing areas omitted for each crop.

(thousands of acres)	
Soybeans	37,795
Dry, edible beans	21,161
Chick-peas (garbanzos)	20,403
Dry, broad beans	11,280
Dry, field peas	9,310
Lentils	896
Total	100,845

Source: USDA, *Agricultural Statistics, 1953,* pp. 136, 310–313, 318, 325.



An agricultural rocket. Soybean acreage jumped from 2 to over 16 million between 1926 and 1952 and the yield of beans per acre doubled. Rivals wheat and oats in Corn Belt crop rotation. At home in several regions. *U. S. Bureau of the Census*

drought resister, and contains three times as much protein as wheat. Its several hundred varieties are adaptable to different environments and uses. This great food plant has undoubtedly seen several thousand years of service in Oriental countries, where it is used in all the forms in which we use beans. Also the oil is extracted from the ripened beans to take the place of butter, and the residue meal is used as fertilizer or livestock feed. Even more surprising is soybean milk, made by slightly fermenting the meal in water, from which a soybean cheese is made.[8]

In the late 1930's China and Manchuria produced over three fourths of the world's soybean crop of nearly 500 million bushels, with most of the remainder coming from other Far Eastern countries. A large export of beans and oil went from Manchuria to northwestern Europe and Japan, but since World War II the total export has been greatly reduced.

Since 1930 the rapid rise of the soybean has been one of the major developments in United States agriculture and has greatly changed the world geography of this crop. During the past quarter-century our production of soybeans increased thirtyfold and reached 331 million bushels in 1954.[9] The major area of production is the Corn Belt, where soybeans provide an excellent soil-improving and cash crop, fit well into the system of mechanized agriculture, and have displaced less productive crops in rotation with corn.

In this country the soybean feeds both man and beast. About 95% of the soybean meal is fed to livestock and poultry, a measure of its excellence as a high-protein feed, with the remainder going largely into breakfast and other foods. Soybean oil, in contrast, has been increasingly absorbed in the food industries producing shortening, margarine, and salad oils, with utilization in a large number of industrial products, such as paint, ink, soap, and plastics expanding less rapidly.[10] In 1953 the United States exported 47 million bushels of soybeans and oil (in terms of beans), while China and Manchuria exported 25 million bushels. Over half these exports went to Europe and about one third to Japan. The soybean boom in U. S. agriculture seems here to stay. Research develops new varieties and new uses and there is even a journal, *Soy Bean Digest.*

3. THE WHITE POTATO

The human engine. An engine needs fuel. The human body may be likened to an engine. It is built largely by protein, the food element furnished by milk, meat, cheese, eggs, most of the nuts, and the leguminous plants, and, to a lesser extent, the grains. Fuel for our human engine is furnished by the carbohydrate group of foods.

Starch, one of the two most universal food elements of all mankind, is classed as a carbohydrate—an energy food. It helps to make fat and heat to keep the body warm and gives

[8] For people of the Far East "the soybean has meant bread, meat, milk, cheese, and vegetables and furnishes what is said to be a well-balanced diet at a relatively low cost," W. J. Morse, "Soybeans Yesterday and Today," *Foreign Agriculture,* May 1948, pp. 91–95. Citation on p. 93.

[9] This makes our production nearly equal to the estimated 350 million bushels for China and Manchuria. USDA, preliminary estimates for 1954.

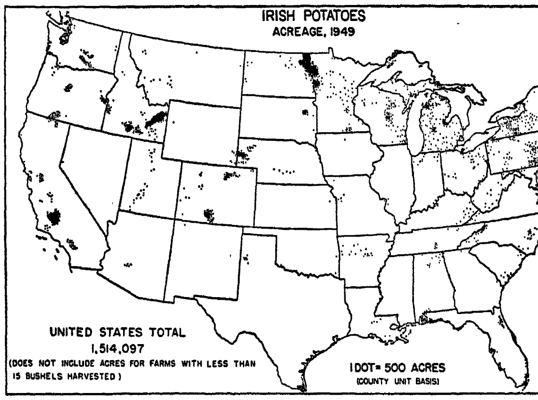
[10] See A. A. Munn, "Production and Utilization of the Soybean in the United States," *Economic Geography,* July 1950, pp. 223–234.

energy for work. Starch is really the surplus nutrition that the plants store within themselves for future needs or for their offspring. Sometimes it is packed in the seeds, as in the grains; or the roots, as in sweet potatoes; or in the peculiar underground stem, as in the white potatoes; or even in the trunks of some of the trees, as in the sago palm.

Distribution and use of the potato. Among the world crops the potato is the greatest in terms of weight and volume, although less important than wheat, rice, or corn in food value. The plant is a native of the Americas, growing wild on Mexican, Bolivian, and Peruvian plateaus, whence it was taken to Europe in the sixteenth century. Since then the potato has certainly established itself as a great cool-climate starch food. It is probably the plant most commonly grown in the vegetable gardens of Europe and America; but its growth as a money crop is quite restricted, offering in this respect a marked contrast to wheat. The potato and rice are rivals in the supplying of starch upon the tables of Europe and America, but the two plants are rarely rival claimants for the same farmer's attention.

Qualifications of a potato country. The potato is a crop of wide climatic range. Cold Alaska as far north as Fairbanks produces regularly, and in 1949 had a crop of 184,862 bushels from 1030 acres, and potatoes are cultivated in the subtropics, as in Florida and Egypt. The potato tolerates a variety of soils. It grows well on land that does well in wheat or corn, but it tends to become important as a main starch food for people and a money crop for farmers in regions that are too cool for corn to grow to the best advantage or have soils too sandy and light for the large yields of small grains. It does not do well on heavy clay. The regions that meet the potato conditions are northern and northeastern United States, Canada, and Europe north of the Alps.

The bulky tuber yields several times as many bushels per acre as does wheat, and therefore it is of great value in enabling land to support dense populations, although a bushel of potatoes is not so nutritious as a bushel of grain. Owing to the laborious method of preparing the seed, the expensive fertilizers necessary, the continuous cultivation, and protection from insects, the potato crop requires more labor than any of the grains common to Europe and America. Hence, potato fields are smaller than grain fields, and the crop is well fitted to intensive agriculture where a small area must, by much labor, be made to yield a large product, such as is necessary in countries of dense populations. The potato harvest, toward the end of summer, leaves the ground in excellent condition for a fine crop of winter grain which usually follows it.



Potatoes are widely grown in the United States, really thrive in the coolness of the Dairy Belt or the western irrigated lands with their cool nights. About a third of the 1949 crop was produced in 6 counties: one each in Maine, California, New York, Idaho, Colorado, and North Dakota. *U. S. Bureau of the Census*

The potato in Europe. The prevalence of cool summers, light, acid soils, and heavy populations makes Europe and Russia the outstanding potato area in the world. The major area of production extends across the plain of North Europe, reaching from the northwest point of France, through Holland and Belgium, Germany, Poland, and the Soviet Union to the Ural Mountains. In all countries north of the Alps, people eat more potatoes (by weight) than grain. Ireland, a land of few resources and cool, moist climate, probably has a greater dependence upon the potato as

a crop for the farm and food for people than any other region in Europe. So great was this dependence that failure of the potato crops in 1845 and 1846 was accompanied by a famine which caused a million deaths and stimulated the emigration of thousands of Irish.[11]

The potato is important to the French. With a population less than one third of ours, they grow 25% more potatoes than we do, the French crop averaging 489 million bushels in 1949–53. The Dutch and Belgians make their small countries produce a surprising amount of potatoes. The production in Holland is about 16 bushels per capita, while the United States produces only 2 bushels per capita.

Germany, with her cool, sandy, northern plains, finds the potato one of the best crops she can grow. For years she was the greatest potato-producing country in the world, although since 1925 her output has been exceeded by that of the Soviet Union and sometimes Poland, a country that has been badly overpopulated. In Russia, which leads the world with an annual crop of more than 2.5 billion bushels, potato production is widely distributed, the heaviest centers of production being located on the sandy plain between Moscow and the Polish border (see Fig. 133).

In Great Britain and the United States the potato is produced primarily for human consumption. In corn-poor northern Europe, on the other hand, its use for animal feed is so important that it is probable that a greater proportion of the world crop is utilized for stock feed than for direct human consumption.[12] Industrial uses, especially for starch and distilled alcohol, are also important in continental Europe and are based on varieties of potatoes developed for these purposes. In Germany during World War II about 20% of the crop was devoted to the manufacture of alcohol, much used as motor fuel; while in the Soviet Union potato alcohol is an important raw material for the synthetic rubber industry.[13]

The potato in the United States. The potato is much less important in the agriculture and food supply of the United States than it is in Europe. As a result of our higher standard of consumption, with its increasingly varied diet, the per-capita consumption of potatoes has declined nearly 50% since 1910. Few potatoes are fed to livestock in view of our fabulous corn crops. Similarly, it has been more economical to produce most of our starch from grains; and alcohol from grains, or as a by-product of the sugar industry. As a result, there has been a major "surplus" of potatoes, buttressed by expensive price supports, despite the fact that we could greatly expand our production without interfering with other crops—if only we could consume the result. In Europe the stock-feed outlet has served as a price controller.

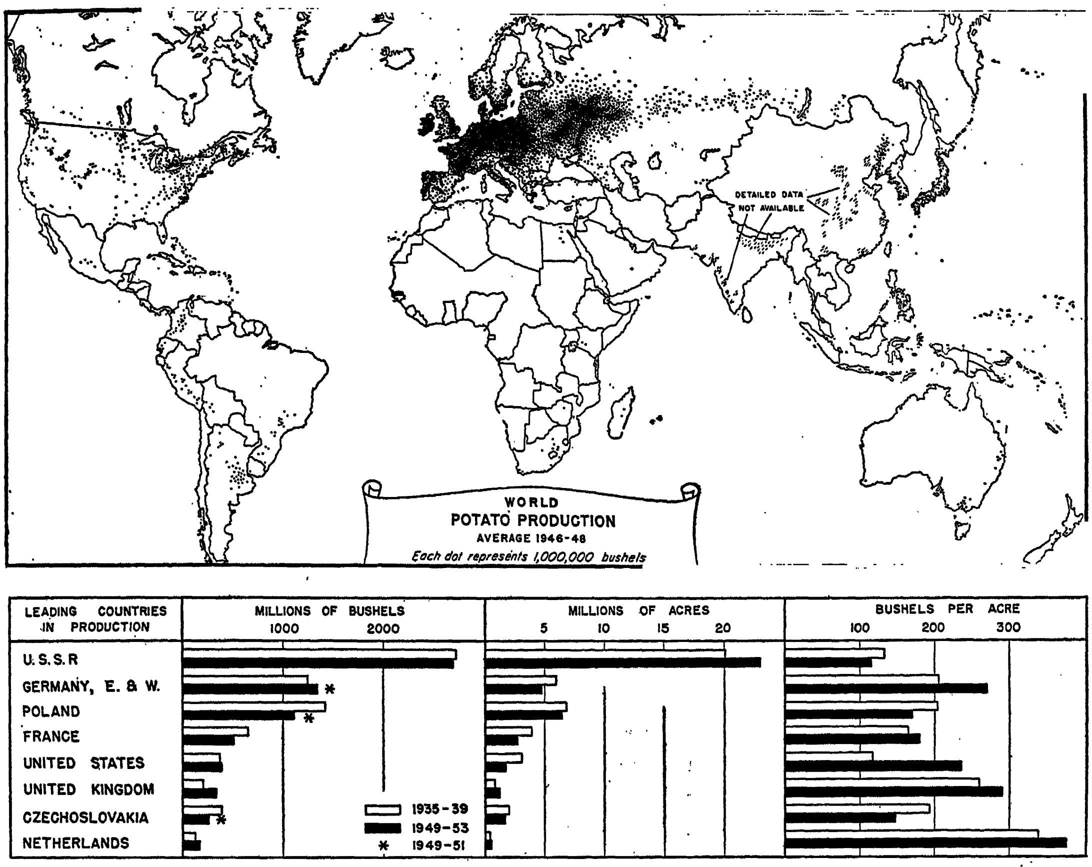
Under these conditions the geography of potato production has undergone substantial changes in recent decades. At the turn of the century potatoes were grown on nearly every farm north of the Cotton Belt and many farmers produced some for sale. Since then, however, total acreage has declined, and commercial production has become increasingly concentrated in a few favored areas, lying north and east of the Corn Belt and in the irrigated areas of the West (see Fig. 131).

The oldest of these areas is Aroostook County, in the St. John River Valley of northern Maine, where a declining agriculture was revived in the 1880's by the rapid rise of potatoes as the commercial crop. Aroostook is still the leading potato county, producing about one sixth of our crop. Another favored area is the Atlantic Plain from eastern Long Island to the tip of the peninsula between Chesapeake Bay and the sea, where the potato producer can take advantage of the sandy soil

[11] R. N. Salaman, *The History and Social Influence of the Potato,* Cambridge University Press, Cambridge, England, 1949, Chaps. XVI-XVII. For the period 1739 to 1895, Salaman lists 23 failures of the potato crop that caused severe distress or famine and 11 less disastrous shortages. *Ibid.,* pp. 603–606.

[12] *Ibid.,* p. 571.

[13] F. J. Stevenson, "The Potato . . ." *Economic Botany,* April-June 1951, pp. 153–171. In peacetime, Germany used about 7% of its crop for industrial purposes.



On this map USA comes out a small potato as to production, and the graph shows that 3 European countries beat us in yield. We are so rich that we don't *have to* make the land work hard, and we don't have to eat so many potatoes. Thank God. More potato possibilities are a great national reserve. *U. S. Department of Agriculture*

and nearness to major urban markets. The valley of the Red River in eastern North Dakota and western Minnesota has emerged as a major commercial area in contrast to the general decline of potato production in the Corn Belt and Lake states.

Since 1930 the most rapid expansion has been in the irrigated areas of California, Idaho,

TABLE 7:1 United States Potato Statistics for Selected Years

	Acres harvested (thousands)	Yield per acre (bushels)	Production (thousands of bu.)	Season average price for farmers ($ per bu.)	Exports (thousands of bu.)	Imports (thousands of bu.)
1900	2,997	87	259,688	.43	741	372
1917	3,801	105	398,653	1.26	3,453	1,180
1929	3,030	110	333,392	1.32	2,386	6,006
1939	2,813	122	342,372	.54	930	1,565
1947	2,001	194	388,985	1.61	16,669	3,462
1953	1,508	248	373,711	.80	4,973	2,309[a]

[a] 1951.

Source: USDA data.

Colorado, and other western states, where special quality or off-season potatoes are produced for eastern markets.[14] These areas have come to specialize, partly because of careful attention to seed selection and production methods on land especially suited for potatoes and partly because of improved transport and marketing techniques. As a result, yields per acre have more than doubled, and in 1952 we produced one third more potatoes than in 1900 from less than half the acreage (see Table 7:1).

International trade in potatoes. Because of their great bulk and weight in proportion to value and because of their perishable nature, potatoes are much less important in international trade than in home production. As a whole, they have a tendency to become a national supply crop, with commerce largely limited to emergencies, early supplies, and seed potatoes. Consequently, exports are usually small in relation to a country's total production, the largest exports from the United States being less than 5% of our crop (see Table 7:1). Cuba and other Latin American countries generally provide our chief market.

Early potatoes from the United States reach Canada in advance of the local harvest, so our neighbor to the north is our second largest customer. During several postwar years half of the record U. S. exports went to Europe, but this subsidized trade has declined greatly since 1949. For the past two decades over 90% of our imports have come from Canada. These are mostly seed potatoes which have developed disease resistance and high productivity in the cool Canadian climate.[15] Here we have a neat example of the exchange between countries of the same crop, but at different times of year and for different purposes.

Europe, the major producing area, is also the main center of international trade in potatoes. However, the transport distances are usually shorter than for many shipments within the United States. Holland, the world's leading exporter,[16] is close to Germany and England, the major importers. Ireland and Denmark also ship substantial surpluses, while Belgium and France both import and export —indicating the complexities of this trade which varies from year to year.

4. SWEET POTATOES AND CASSAVA

Sweet-potato production in the United States. The tropic zone is often said to have great possibilities for the support of human life. One evidence of this is the great abundance of starch-producing plants, one of which is the sweet potato—causing the tropic denizen to have small regret over the fact that the white potato will not grow there. The sweet potato supplies the same need in human diet as the white potato, and is actually superior to it in food value and vitamin content.

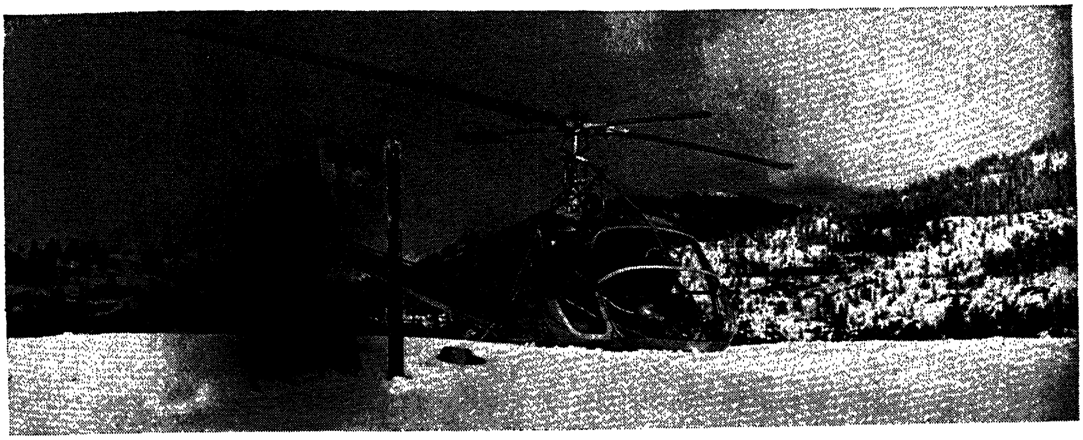
The sweet potato is a perennial where there is no frost, yet it will grow a crop in the warm summer as far north as Iowa or New York. Fortunately, it requires even lighter and sandier soil than the white potato and is, therefore, much grown on the sandy lands of the Coastal Plain from New Jersey to the Carolinas for shipment to northern markets. Similar sandy spots in Louisiana and Texas serve the interior of the United States and Canada. Over 90% of our sweet-potato acreage is in the southern states, and over a quarter of the recorded production is consumed in the households of the producing farmers.

Sweet potatoes are an excellent source of starch, and tests have also shown that, in

[14] For example, Kern County, California, where significant commercial production dates from the late 1920's, is now second only to Aroostook County. Kern County potatoes are grown under irrigation and harvested in May and June, supplying about 60% of the nation's supply during this period. It requires 6 to 8 trains a day, each with 75 or 80 refrigerator cars, to move the crop to markets mostly east of the Mississippi. "Traffic Story, Cross Country Potato Race," *Railway Age*, August 10, 1953, pp. 101–103.

[15] This advantage is shared by Maine, Minnesota, and North Dakota which generally produce about three fifths of our domestic supply of certified seed potatoes.

[16] Holland exports from 10% to 15% of her crop and shipped over twice as many potatoes as did the United States during the 1945–49 period of heavy U. S. exports.



California leads by far in vegetables, most of them irrigated. How much water will there be next August? Helicopter surveyor on mountain snow helps to figure it out months in advance. ***United Helicopters, Inc., Palo Alto, Calif.***

dehydrated form, they rival corn in feed value for livestock. Important developments along these lines may lie in the future for which it is a food reserve.

The importance of the sweet potato in East Asia and the tropics. China is the most important area of sweet-potato culture, with an estimated 40% of the estimated world production in 1951.[17] This valuable food appears to have been introduced into China from the Philippines in 1594 as the result of efforts to find a crop which would relieve frequent famines.[18] Adaptable both to the subtropic south and the drier climate of the North China Plain, it is now widely grown as a local food crop on the mainland as well as on the islands off the east coast of Asia from Java to Japan. Sweet potatoes are a major food crop for millions of northern Chinese who seldom eat rice.

It is also a universal food crop in the wet tropics, its original home, whether in the Spanish-speaking settlements of South America or English-speaking Honduras; the West Indian Islands, the coasts of Africa, or the islands and peninsulas of Southeast Asia. Some varieties called yams grow large enough to weigh 40 or 50 pounds, but they have no commercial importance in the tropics because of their many rivals, the universal ease of their production, and the fact that there are few tropic cities large enough to require large movement of agricultural products. The low-valued sweet potato does not travel far.

Cassava. The garden in the rainy tropics always has some form of starch roots ready to dig. Cassava, or manioc, is one of these rivals of the sweet potato that helps to fill the local need for a principal starch or bread-substitute food. In addition to its nutritious starch, the cassava root also contains the virulent poison known as prussic acid. Fortunately, this poison is volatile and is dissipated by exposure to the sun or moderate heating, so that, while predatory insects and rodents cannot eat the raw roots, the cooked roots can be eaten with perfect safety.

Cassava grows best in rich, sandy loam and needs abundant moisture. It keeps better than the sweet potato under tropical conditions. The plant reaches a height of 8 or 10 feet, and develops roots about 2 inches thick and sometimes as much as 6 feet long. It is native to

[17] Estimated Production of Sweet Potatoes and Yams, 1951

	Thousands of tons
Asia	33,500
Africa	17,200
Latin America	2,582
United States	719
Oceania	80[a]
Total	54,081

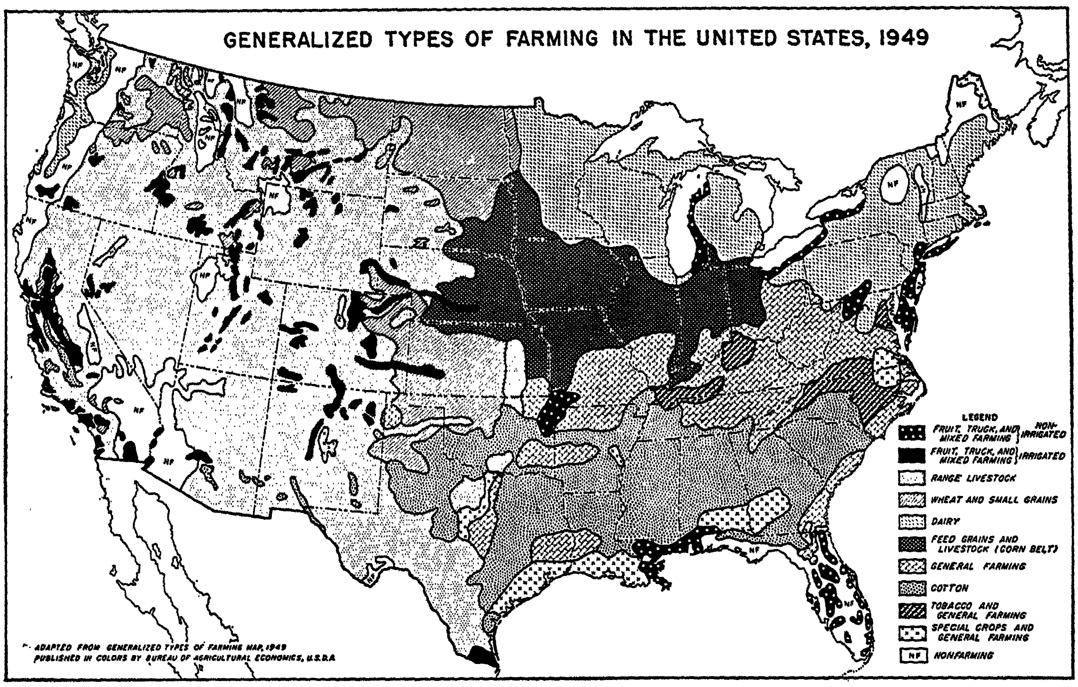
[a] 1950.

Source: U. N., Food and Agriculture Organization, *Yearbook of Food and Agricultural Statistics, 1952,* Part I, pp. 52–53.

[18] See J. S. Cooley, "Sweetpotatoes—World Production and Food Value," *Economic Botany,* January 1948, pp. 83–87.

Tropical America and, since Columbian times, has been widely distributed throughout the equatorial regions of Africa and Southeast Asia. In all these lands cassava is a standard article of diet for the natives and replaces to a considerable extent the cornbread of the American South, the boiled potatoes and rye bread of the European peasant, and all other breadstuffs of the temperate zone. In Java, for example, cassava follows rice and corn as the third most important foodstuff. Grown without irrigation and on poorer soils, it makes a vital contribution to the food supply of this densely populated island.

Aside from local exchange, commercial production is unimportant. In Brazil cassava flour (farinha) made by shredding and drying the root is sold in many interior villages. Cassava is also the source of the tapioca consumed in the temperate zone.[19]



Do you understand this? It is a good review of U. S. agriculture. Solid blacks in the West are mostly irrigation. *U. S. Department of Agriculture*

[19] R. W. Schery, "Manoic—A Tropical Staff of Life," *Economic Botany,* January 1947, pp. 20–25.

fourths of the total originates in countries of the Caribbean area from Mexico to Ecuador and including the West Indies. Most of the rest comes from western Equatorial Africa. Together these areas are but a small part of the potential banana lands of the earth.

Central American and West Indian bananas reach New Orleans or Galveston in from 3 to 5 days; the trip to New York or Philadelphia takes 6 or 7 days. The supply in Europe is inferior to that in the United States, because that part of the tropics lying nearest Europe is the Desert of Sahara where the banana cannot grow. The closest producing area for Europe is the Canary Islands, which have long shipped bananas. In recent years, however, larger shipments have come from western Equatorial Africa—especially the Cameroons, French West Africa, and Nigeria—where commercial production is expanding. Meanwhile nearly half of European imports come by fast steamer from the West Indies and Central America. In the Southern Hemisphere, New Zealand and South Africa are small importers and Brazil has become a major exporter, with Argentina and Uruguay her chief markets.

Importance in Caribbean countries. The nearness of the United States to the steaming hot plains that border the Caribbean Sea and the Gulf of Mexico has given us a favorable place from which to draw our supply of bananas. Similar conditions also favor important banana production along the Pacific coasts of Ecuador and Colombia. Owing to the unwholesome climate of these hot and humid coasts, nearly all the people live in the more healthful interior uplands. Particularly in Central America the banana lands had long been idle until the plantation development brought white overseers and West Indian Negroes to the low eastern coast from Panama to Mexico.

Banana production on a commercial scale requires capital and organization such as only big industry can provide. Consequently, the small, independent, native producer is less important in the banana industry than in the production of certain other tropical crops, such as cacao, rubber, copra, and even coffee. However, the big companies buy bananas from small producers in the vicinity of the plantations, and the native producer is important in the commercial production in the West Indies, northern South America and West Africa.

The large plantations, with their railways, villages, stores, schools, hospitals, radio stations, docks, and ships, are owned by private corporations, and the land is worked by thousands of native laborers under the supervision of northerners. The United Fruit Co. owns hundreds of thousands of acres of land scattered in half a dozen countries, ships millions of bunches annually, and controls every step in production from the clearing of the plantation site to the final delivery of the fruit to the consuming market.

In most countries of Tropic America people have a double dependence upon the banana. It is a great supply crop because it is a standard article of food, and to many of the people it is also a very important money crop. But as a commercial export crop, the banana is subject to the vicissitudes of plant disease, weather, and politics. Old producing areas decline, sometimes to revive, while new areas rise in importance in the export trade. In 1946–47 five countries supplied over three fourths of the bananas shipped to the United States. In order of importance the five were Honduras, Guatemala, Mexico, Haiti, and Costa Rica. By 1953–54, however, this list and its order had changed to Ecuador, Honduras, Costa Rica, Panama, and Colombia.

Difficulties of banana growing. The banana is a vulnerable crop with special hazards of its own. A hurricane sometimes beats to shreds the banana plantations of an entire district, and a severe hurricane is indeed a national calamity. High winds in May and June 1923 did $1,250,000 worth of damage on the east coast of Honduras. As a form of hurricane insurance, the United Fruit Co. has its plantations widely distributed in Cuba, Jamaica, Guatemala, Costa Rica, Honduras, Nicaragua, Panama, and Colombia so that no single hurricane can get them all. The com-

pany knows that it would be bad business to put all of its bananas in one country.

Two plant diseases, Panama disease and sigatoka, are greater hazards than hurricanes to banana cultivation. Plant diseases thrive in the constant heat and humidity of the Rainy Tropics, especially where a single crop is planted over a considerable area. Therefore, agriculture in the tropics provides many examples of abandonment of areas of commercial production and drastic changes in the importance of different countries as suppliers of particular crops. The banana is no exception. The Panama disease affects the root, causes the plant to rot, and infects the soil so that it cannot be planted in bananas for years, unless it be completely covered with water for a season.

By 1910 thousands of acres of banana land along the Caribbean coast of Central America had been affected, and the disease was more important than soil exhaustion in causing the United Fruit Co. to abandon banana land regularly after a few years and to bring new land into cultivation. The year 1913 marked the peak of banana exports from the east coast of Costa Rica, but a second blow fell later. Sigatoka, a leaf disease seriously decreasing the amount and quality of production, appeared in Trinidad in 1933 and quickly spread throughout the Caribbean area.

This combination of diseases, soil exhaustion, and hurricane danger stimulated the rapid development of banana production on the drier west coast of Central America. In Costa Rica, for example, annual banana exports since 1950 have exceeded the 1913 peak, but over 80% have come from the west coast, and a comparable shift has occurred in Guatemala. Despite much effort, no effective and economic control for Panama disease has been found, and abandonment is still the rule.

Sigatoka can be controlled by spraying with various preparations containing copper, and this is more effective on the drier west coast. Even here, however, it requires an investment in pipe and pumps equal to the cost of initial land clearing, and occupies about a third of the plantation's labor force.[1]

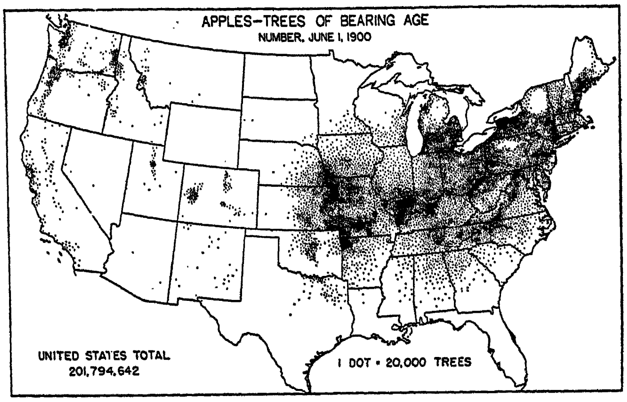
Getting ready to plant bananas, Almirante, Panama, 70 miles east of Colon. Note vines on tree, broad banana leaves at left. Let the tree lie, and the ants will eat it in about a year. Meanwhile banana shoots will be planted within a few feet of this stump, and hand chopping will keep the jungle down while bananas grow. ***United Fruit Co.***

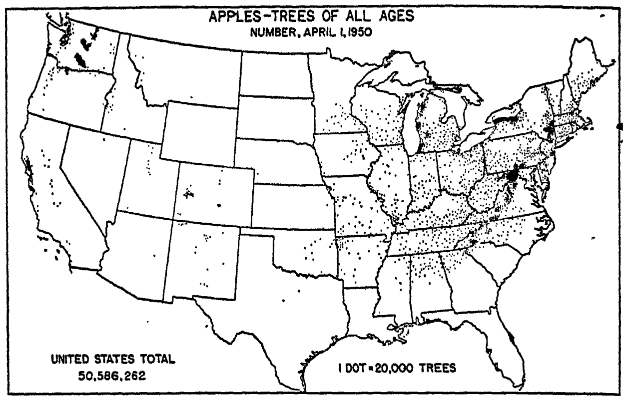
In Ecuador the two diseases, though present, are not yet major problems. This is one factor influencing this country's rapid rise from tenth (1946–47) to first place (1952–53 and 1953–54) among the world's banana exporters. But in view of the industry's fluctuations in other areas, predictions would be rash. In the tropics man's struggle with plant, animal, and human diseases is expensive and continuous.

2. THE APPLE

Changing position of the apple in America. Johnny Appleseed was a real person. His

[1] See C. F. Jones and P. C. Morrison, "Evaluation of the Banana Industry of Costa Rica," *Economic Geography*, January 1952, pp. 1–19. In Costa Rica, the United Fruit Co. abandoned its east-coast plantations in favor of the west coast prior to the sigatoka outbreak. The company continues to operate in the old banana area, but produces cacao and abaca. Perhaps such diversification holds promise for other abandoned banana lands.





Why the difference? Competition of orange and other fruits; European competition; European poverty; pests that increase cost of spraying and other care. Each tree yields more now. In 1899 many were farm orchards of low productivity. Farm orchard gone. *U. S. Bureau of the Census*

name was John Chapman, and for 40 years before his death in 1847 he traveled through western Pennsylvania, Ohio, Indiana, and Illinois tending the apple nurseries he had set in the wilderness and helping hundreds of frontier settlers to start orchards.[2] His efforts lasted and bore fruit for a long time because the apple tree is a long-lived, hardy tree and is adapted to a wider range of soil conditions than any other important fruit. These characteristics made a few apple trees for family supply a natural part of the equipment of almost every American farm from Maine to eastern Nebraska and Kansas, from Wisconsin to northern Alabama, and in favored areas west of the Great Plains. By 1900 there were over 200 million apple trees in the United States (compare the maps on this page).

This distribution has been drastically changed during the last 50 years by two developments: the decline and the commercialization of the apple industry. Thousands of acres of orchard have been abandoned or put to other uses, and in 1950 there were less than one fourth as many trees as in 1900. The annual crop, which frequently exceeded 200 million bushels around the turn of the century, ranged from 88 to 134 million bushels between 1948 and 1953.

Apple production in "home" orchards now accounts for less than 20% of the total crop. This change to commercial production, characteristic of most fruit and vegetable farming in the United States, has often been accompanied by a reduction in their cultivated areas. Under these conditions the survival of an apple-producing area has depended on its location, the local environmental conditions, and the production and marketing skill of the growers. Three types of area have emerged as the major commercial producers: the irrigated valleys of the West, the valleys and lower slopes of the Appalachians, and the shores of the Great Lakes. Three states containing areas of these types generally produce from a third to a half of the commercial crop: namely, Washington, New York, and Virginia.

Irrigated apples of the West. In the more newly settled states of the Rocky Mountains and north Pacific coast there are many irrigated districts that produce large and beautiful apples. Some of these, as the Hood River valley in Oregon and the Yakima, Okanogan, and Wenatchee valleys in Washington, have become well known in the eastern part of the United States through the beautiful fruit they send out. For some years the state of Washington, aided by irrigation and care, has led all others in commercial apple production, with an average annual output of 26½ million bushels during 1941–52. Parts of Idaho, Montana, and Colorado and a few sections of north-

[2] See H. A. Pershing, *Johnny Appleseed and His Time*, 1930; and also Walt Disney's movie featuring the same character. The pioneers of today are plant breeders producing new varieties.

ern California are equally well fitted for the growth of this fruit.

Because of the bright sunshine of the semi-arid climate, western apples are the most highly colored in America. These western fruit districts, which must be in the valleys, are of restricted area because of the limitation imposed by soil requirements, irrigation, water drainage, air drainage, and protection from strong winds. California apples are grown chiefly in the Coast Range and coastal valleys in the central part of the state.

Production in the Pacific Northwest expanded rapidly after 1900 and has declined only slightly from its peak in the late 1920's. Careful attention to the quality and marketing of their product has enabled northwestern producers to sell on the eastern markets despite high transport costs. In recent years more northwestern apples have been sold in the growing cities of the South and the Pacific Coast where there is less competition from other apple areas.[3]

Lake-shore apple districts. New York ranks second to Washington as a commercial producer of apples, with an average output of 14 million bushels during 1941–52. There are many orchards in the lower Hudson Valley, but New York's major apple district lies in a narrow strip along the southern shore of Lake Ontario with Lake Erie to the west. These large bodies of water, with their melting ice in spring, serve to delay the blossoming time until there is small danger of injury from frost. Likewise in autumn the warm waters of the lakes delay the killing frosts. These advantages have aided the development of fruit and vegetable growing in the lake-shore districts where general farming was the rule before the competition of cheaper meat and grain from the Midwest.

The lower peninsula of Michigan is important in the production of apples for reasons very similar to those prevailing in western New York. The great development of apple orchards close to the eastern shore of Lake Michigan, and their striking absence on the west side, serves to emphasize the combined influence of the lake and the prevailing westerly winds. Michigan competes with Pennsylvania and California for fourth place among our producing states. (See Fig. 140, right.)

The Appalachian apple district. The third commercial district extends for 500 miles along the Great Appalachian Valley from southern Pennsylvania to southwestern Virginia and spreads into the mountain areas on each side. Virginia occupies the larger part of this district and its 10-million-bushel crop gives it third place. The apple industry is most important in the northern part, in the Cumberland-Shenandoah area of Pennsylvania, central Maryland, and northern Virginia and West Virginia. Another important orchard district lies along the eastern foothills of the Blue Ridge near Charlottesville in central Virginia. Elsewhere in the Appalachian district orchards, though important, occupy a relatively small proportion of the agricultural land.

The eastern states from North Carolina to Maine produce from 40% to 50% of our commercial crop and share a geographic advantage in their nearness to the eastern city markets. This advantage has been enhanced by the increase in truck transport in recent years. In 1951, 73% of the apples unloaded at New York, Philadelphia, Baltimore, and Washington arrived by truck from eastern areas and 24% by rail from the West (chiefly Washington). In 1939 only 57% had come by truck, indicating a relative decline in the importance of western apples in these markets.

The competition of Washington apples is still keen, however, and has forced eastern producers to pay more attention to the quality and marketing of their product. Eastern producers also depend more upon sales to processors, who take about half the crop produced in New York and the Applachian states and

[3] See Hoyt Lemons and Rayburn Tousley, "The Washington Apple Industry," *Economic Geography,* Vol. 21, 1945: "Part I, The Geographic Basis," pp. 171–182; and "Part II, Economic Considerations," pp. 252–268. Citation on pp. 259–261.

Spraying apples. Eight or ten costly sprays, plus equipment, plus fertilizer, plus pruning, picking, grading, packing, and packaging, make apple growing costly. Other fruits similar. *David G. Whote, Rutgers University*

pack nearly 90% of the nation's canned apples and applesauce.[4]

Problems of the apple industry. The apple producer, like all agriculturalists, faces many production hazards. An apple tree, like most other trees, will rarely bear two heavy crops in succession. This fact, in combination with occasional injuries by frosts, hail, fungus, and drought, makes it exceedingly rare that all the different surplus apple districts have a full crop at the same time. When they do, as in the year 1896, the crop exceeds the demand, and they have almost no value (75¢ per barrel in March 1897). In 1926, 1937, and 1949 millions of bushels were not picked.

As a result of our world commerce and the introduction of new varieties of plants, each locality also gets nearly all of the world's weeds and plant enemies. Thus came many insects, fungi, rusts, and other plant enemies which combine to destroy nearly all the fruit that forms on the trees of the unprotected orchard. Fortunately, they can usually be held in check by skillful care, much of which consists in spraying poisonous liquids on the trees. This makes the production of good fruit one of the most scientific of all pursuits, and, aided by the development of refrigeration and modern marketing methods, has transferred it from the small orchard of the general farmer to the larger orchard of the specialist in the better located fruit districts.

A declining market has been a fundamental condition for these changes. Consumption of fresh apples has dropped from 59 pounds per person in 1910 to 21 in 1952, although per-capita consumption of all fruits, fresh and processed, rose from 144 to 156 pounds during the same period.[5] Exports of fresh apples have also declined to around 3 million bushels a year, in contrast to a range from 11 to 29 million bushels (at least 10% of our crop) in the years 1925 to 1938.

Under these conditions commercial production has virtually disappeared from large areas (see Figs. 140). Even within the commercial areas which have remained important, such as Washington and the Appalachians, orchards

[4] Virginia Polytechnic Institute, Agricultural Experiment Station, *Bulletin* No. 462, "Some Recent Trends in the Appalachian Apple Industry," Blacksburg, 1953, pp. 28–31, 37–44.

[5] USDA, *Agricultural Statistics, 1953,* pp. 218–219.

have been pulled up or abandoned on land which, for one reason or another, is not able to maintain production in a highly competitive industry.

Canadian apple districts. In Canada the apple does well from Lake Huron to the mouth of the St. Lawrence, and two localities have utilized their especial advantages for developing the apple as a money crop. The most famous apple district in Canada is the narrow Annapolis-Cornwallis Valley in the western part of Nova Scotia, which is warmed by the Bay of Fundy and protected from winds by a sheltering mountain range and is well suited to the apple. These advantages, together with an early start and convenient access to a harbor, have given it a development of apple growing that has made its product world-famous.

This valley produces over one third of the commercial crop, and apples for shipment to other parts of Canada and export are the chief money crop and financial dependence of its people. The other eastern-Canada apple district nestles itself between Lakes Erie and Ontario. Here it has the protecting influence of the water similar to that which benefits the New York lake shore apple belt, of which it is really an extension separated only by the Niagara River.

In British Columbia a third apple district lies in the dry Okanagan Valley and is virtually an extension of the irrigated fruit district in the state of Washington. Although producing half the Canadian crop in some years, the Okanagan Valley has the disadvantages of distance from the major Canadian cities and heavy dependence on the export market.[6] Canada maintains its prewar output of about 15 million bushels, but exports, which were previously around 40% of the crop, have been cut in half. Like the United States, Canada has been hit by the decline in European imports of North American apples from an average of 13 million bushels in 1935–39 to less than 3 million in 1951 and 1952.

European apple growing. Apples are at home in Eurasia from Edinburgh to the Mediterranean, from the Bay of Biscay to Tokyo. They also fit well into the intensive agriculture of the small European farm, especially in the hilly and mountain valley areas of France, Germany, Italy, and Switzerland, the leading producers. Western Europe leads the world in apples. Production has nearly doubled[7] since the late 1930's, and Europe is becoming more self-sufficient. She could and should produce all she needs. The Netherlands is now an apple exporter.

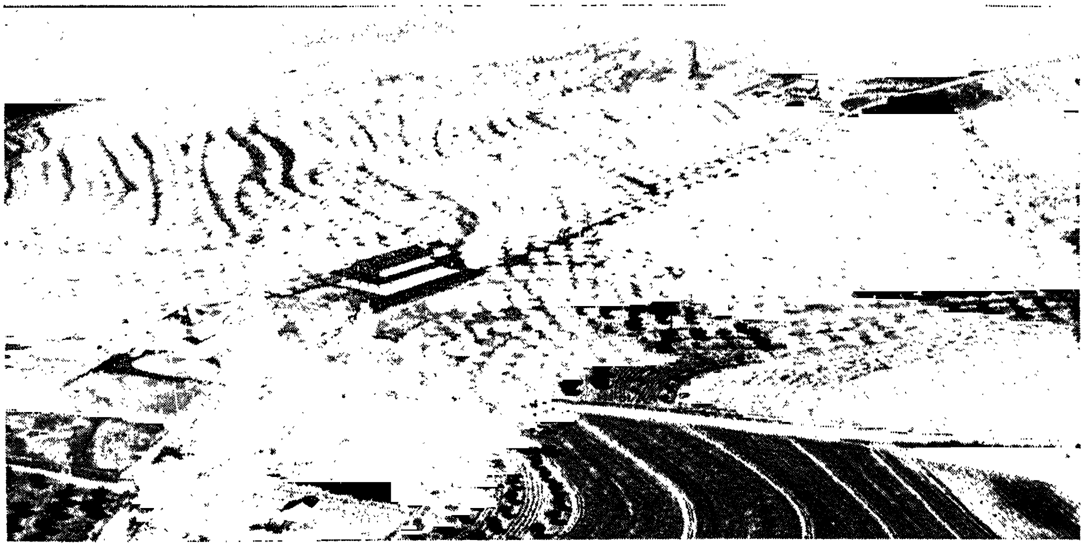
Intra-European trade has increased greatly as a result of expanded production, improved marketing methods, and the difficulty of imports from the "dollar area" of United States and Canada. In 1951 and 1952 the Netherlands and Italy each exported more than 5 million bushels a year to become the world's leading exporting countries.[8] Great Britain and Germany remain the major importers, with domestic and imported apples also moving to the cities and industrial areas of the Low Countries, France, and Switzerland.

The apple in the south temperate zone. The south temperate zone, with the reverse arrangement of its seasons, can send its fresh autumn fruits to the north at the end of winter when ours are gone or have been longest in storage. The south temperate zone has climate and resources that seem well suited to the apple, particularly New Zealand and the island of Tasmania, which is about as large as West Virginia. It much resembles this state in its mixture of mountain and valley, its good rainfall, and its suitability to the apple. South New Zealand with a similar climate is another important producer. Australia has had a marked increase of apple growing, particularly in Victoria, where they are the main fruit crop. In

[6] Donald Putnam, *Canadian Regions, A Geography of Canada,* J. M. Dent & Sons, London, 1952, pp. 450–451.

[7] Average production in western Europe of 126 million bushels (1935–39) rose to 227 million bushels (1949–53). Figures do not include cider apples (157 million bushels, 1949–53), produced mainly in France. Source: USDA, *Foreign Crops and Markets,* April 13, 1953, and Sept. 21, 1953.

[8] USDA, *loc. cit.,* July 13, 1953, pp. 18–19. Exports from the United States and Canada were 6,976,000 in 1951 and 4,749,000 in 1952.



Terraced peach orchards and crop land, Spartanburg, S. C., almost stop erosion. At the edges of these strips drains carry water slowly away. ***U. S. Soil Conservation Service***

addition to supplying the local demand, these countries have been able to maintain the pre-war level of exports aided by close cultural and financial ties to Great Britain.

Irrigated orchards in the Mediterranean-climate areas of South Africa and central Chile have been the basis for other exports from the Southern Hemisphere. However, both have been outstripped by the rapid expansion of Argentina's production in the Patagonian valleys at the eastern base of the Andes from which an increasing export moves to Brazil and western Europe. Compare the valleys in Patagonia and the Pacific Northwest.

3. THE PEACH

The perishable nature of the peach and its commercial effect. This delicious fruit is regarded as more of a luxury than the apple, chiefly because by its perishable nature it is less adapted to being a staple of commerce. The standard market peaches cannot be kept in good condition more than 10 days or two weeks without excessive cost, while some varieties of apples will keep in storage from October until June. But such is the high esteem of this fruit that, since the coming of fast trains, refrigerator trucks, and steamships, it is marketed all over the United States and Europe and even sent across the ocean.

In the United States peach production has increased during the last half-century in contrast to that of the apple. This is partly due to the greater palatability of the peach from the can. The canned peach pack has more than doubled in the past 20 years and over a third of the crop is now marketed in this form.[9] In this way the difficulty of transporting fresh peaches is partially overcome.

In addition to the perishable nature of its fruit, the peach tree itself is much less hardy than the apple. It has two chief climatic perils: early bloom and spring frost injury to blossoms, and winter killing of buds and trees by cold weather. Therefore it yields well only in restricted localities and under special climatic conditions. The United States has several such districts with relatively mild winters and some immunity to early spring frosts.

The eastern peach belts. Peaches are grown along the shores of the Great Lakes for the same reasons that caused the apple to be important. The eastern shore of Lake Michigan is the most important, with smaller areas

[9] Annual average data for the years 1948–52 from various USDA publications:

(millions of bushels)

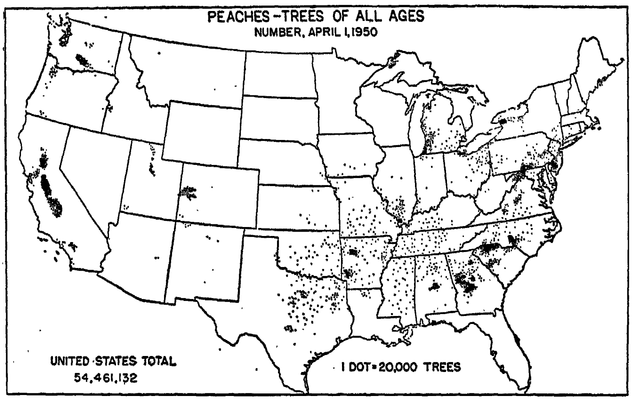
Peach production	61.3	—50% *above* 1900–04 average
Apple production	105.8	—46% *below* 1900–04 average
Peaches canned	23.5	—38% of average crop
Apples canned	12.4	—12% of average crop

along the southern margins of lakes Erie and Ontario (See Fig. 145). Peach growing is also important in Appalachia. The advantage of the hill over the plain is due to two climatic factors. First, the coolness of elevation makes a later start in spring growth. The second advantage is air drainage. Cold air is heavier than warm air, and upon frosty nights it settles to the lowland where fruit buds freeze, while the hills are frost-free. Owing to this advantage, a peach belt developed rapidly upon the mountain slopes of the Blue Ridge and the Alleghenies in the Potomac drainage basin in southern Pennsylvania, western Maryland, and the eastern part of West Virginia.

From this area trunk line railroads gave direct train service to Chicago, Boston, and points between, but the truck is getting an increasing share of the transport. The peach crop is highly seasonal. The Potomac Valley does not compete with the shore of Lake Ontario, and Georgia does not compete with Maryland. Upland orchards at the southern end of these Appalachian highlands cause Georgia, South Carolina, and North Carolina to send hundreds of cars of peaches per day to northern markets for a time in July. The several peach areas in these three states generally produce 10% to 15% of the national crop and have become more important than either the Appalachian or the lake-shore districts.

California peach growing. California is the greatest peach district of all, with 52% of the nation's crop in the years 1948–52. In fact, the increase in California's production since 1900 has been greater than the increase in the United States total.

Most of the peaches are grown in the Great Valley, especially the San Joaquin portion, where thousands of acres are under irrigation. From 10% to 15% of the crop is marketed fresh in California, with about half as much shipped to other states. The perfection of California methods of picking, packing, and shipping make it possible to send peaches to markets east of the Rockies and even overseas. However, most of the crop goes to the cannery, the large-sized, firm-fleshed California canned



The peach seeks the even temperature of altitude and shore lands. ***U. S. Bureau of the Census***

peach being such a favorite on the market that over 90% of our canned peaches come from this state.

The peach in Europe. In Europe, as in the United States, the peach does best in the Mediterranean-climate region. Italy provides half, with France and Spain another quarter of Europe's production. Germany, with its warm southern valleys, is the leading producer north of the Alps. But Germany, together with Great Britain and Switzerland, import substantial quantities, chiefly from Italy. Given good transport facilities and fewer trade and monetary restrictions, there is no reason why northwestern Europe could not enjoy a cheap and abundant supply from Mediterranean Europe and North Africa.

Production in the Southern Hemisphere. The peach does as well in the south temperate zone as it does in the north temperate zone. Peaches of excellent quality are grown in Chile, Argentina, Australia, New Zealand, and South Africa, but chiefly for home consumption. Small quantities are exported to Northern Hemisphere markets in February and March, but this is a limited luxury market due to the transport costs and spoilage en route.

4. THE CITRUS FRUITS

The difficulty of transporting tropic fruits. The citrus fruits, including the orange,

the lemon, the grapefruit or pomelo, the tangerine, the lime, and several others of small commercial importance, are the advance guard of the tropic fruit supply. People of the north temperate zone are enabled to have these fruits on their tables because of the tough, thick, oily, and bitter skin that serves as an effective protection against insects, bruises, and decay, while a host of delicious tropic fruits remain practically unknown to commerce because they lack such natural protection. Improved transport, including the airplane, now allows a small trade through which we are slowly overcoming our dietary conservatism and stimulating our taste for these delicious and tender tropical fruits. The Japanese persimmon and the mango,[10] good examples of this, are already arriving in small quantities. Avocado production, 25,000 tons in California and Florida, plus imports of 3000 tons from Cuba, may be said to indicate that this crop has arrived.

The world pattern of citrus production. The expansion of the citrus industry has been a striking feature of world fruit production and one which has continued in recent years (see Table 9:1). Whenever and wherever they could afford it, people have increased their consumption of these tasty, health-giving products. As a result, two major consuming areas have emerged, North America and northwestern Europe, where living standards are relatively high and population is numerous. Citrus fruits are bulky and expensive to transport. Therefore, production has become concentrated in the subtropical regions closest to the major market areas, even though many of these producing districts "are climatically marginal for citrus fruits."[11]

In North America the citrus districts in Florida, California, Texas, and Arizona supply the needs of consumers in the United States and Canada and export little to other areas. For Europe, the countries bordering the Mediterranean Sea are the major sources of supply. These two subtropical zones of production produce 70% of the world's oranges, 85% of the lemons, and 93% of the grapefruit. Tropical and subtropical areas in southeastern Asia and the Southern Hemisphere account for most of the rest.

Importance in Mediterranean climate. It was in the Mediterranean countries that the citrus fruits first gave rise to great commerce. The combined warming influences of the Mediterranean Sea, the Sahara Desert, the Atlantic Ocean, and the mountains protecting from the north wind make this the most northerly of all regions with climate warm enough for these fruits. A short distance away are the millions of people of northern and western Europe, connected with the citrus lands of the south by steamer and numerous railroads.

TABLE 9:1. Major Citrus Areas—Production and Export
(thousands of boxes,[a] 5-year averages)

	Production 1935–39	Production 1948–52	Export 1948–52
Oranges			
United States	67,034	116,357	6,107
Medit. Basin	59,332	82,850	35,042
World[b]	213,365	295,991	49,907
Lemons			
United States	9,552	11,904	334
Medit. Basin	12,423	11,817	5,985
World[b]	23,310	27,936	6,329
Grapefruit			
United States	31,787	41,426	1,637
Medit. Basin	1,508	1,490	924
World[b]	35,246	45,888	3,421

a A box of oranges weighs 70 pounds; of lemons, 76; and of grapefruit, 80 pounds.
b "World" includes all areas for which data are available.
Source: Compiled from USDA publications.

Much can be gained from a careful study of this table.

Spain and Italy. The three peninsulas of Europe which project far south—the Iberian, the Italian, and the Grecian—are important citrus producers. The orange is found on the west coast of Portugal as far as 40°N. Lat.

[10] The mango, a delicious fruit as much used in the tropics as we use the apple and peach, is cultivated in India to the extent of a hundred named varieties. We could easily get them from the West Indies if the demand existed.

[11] See Edward A. Ackerman, "Influences of Climate on the Cultivation of Citrus Fruits," *Geographical Review*, April 1938, pp. 289–302. Citation on p. 289.

Orange districts skirt the southern and eastern coasts of the Iberian Peninsula, but the interior is too high and too cold for this fruit except in the plain of Andalusia. The most important Spanish orange-growing district is on the irrigated plain of Valencia, near the central part of the eastern coast. Spain exported 24½ million boxes in 1952 and is by far the leading exporter, generally supplying from one third to one half of the world shipments.

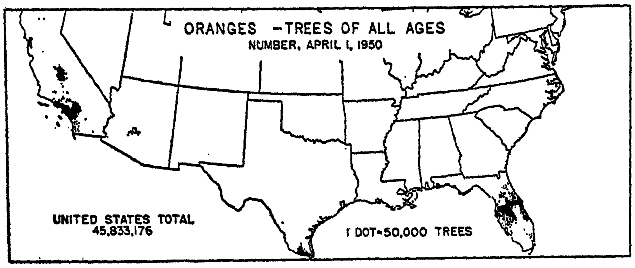
The citrus industry is nearly as important to Italy as it is to Spain, Italy possessing an orange or lemon tree for every two persons in the whole country. The most northerly citrus districts in the world are found in latitudes 44° to 46° on the protected coast around Genoa and along the shores of Lake Garda at the foot of the Italian Alps. However, Italy's most important citrus areas lie along the coast of the peninsula south of Naples and especially in the island of Sicily, where the surrounding waters of the Mediterranean afford frost protection.

Since lemons are more subject to frost damage than oranges, Sicily produces nearly all the Italian crop and also has about 60% of the country's acreage in oranges. The Italian and Sicilian peasants give these fruits the greatest care. South of Naples they can be grown only in those few spots that can be irrigated. The ground is usually cultivated with the hoe and spade, garden crops are often grown between the trees, and much of the soil is so steep that it is kept from washing into the Mediterranean only by the laborious building of terraces restrained by stone walls. It is chiefly this intensive kind of agricultural industry that has given to rugged and arid Sicily a population of 403 persons to the square mile. Citrus fruits usually account for more than two fifths of all Sicilian exports. Including shipments from Sicily, Italy's export of about 6 million boxes of oranges is about equal to that from the United States but considerably below the exports from Spain and French North Africa. In lemons, however, Italy leads the world, her annual export of 4½ million boxes being about three fourths of the world total.

Other Mediterranean areas. Countries around the eastern Mediterranean from Greece to Egypt are also important producers of citrus fruits. Among these Israel and Palestine are the leading exporters, shipping about 3½ million boxes of oranges and nearly all the grapefruit exported from Mediterranean countries. Postwar exports from these countries are much below the 1935–39 average when Palestine was second only to Spain in the export of oranges.

The most rapid expansion of citrus production in the Mediterranean area has taken place in North Africa, especially Algeria and French Morocco. Although most citrus crops are grown, oranges are by far the most important. European settlers have planted thousands of acres on irrigated land along the Mediterranean coast of Algeria where the most important of several districts are near the cities of Oran and Algiers. The main producing area in Morocco is in the northwest on the Atlantic coastal plains. In the years 1948–53 these two countries produced 12½ million and exported 8½ million boxes of oranges per year—a fourfold increase over the 1935–39 averages. France is the major market for North African citrus, but the Mediterranean industry will become increasingly competitive as the older producing districts regain their prewar levels of production.

New citrus lands in the Southern Hemisphere. The fruits of the Southern Hemisphere have the immense advantage of ripening at about the time when those of Europe and the United States have been consumed. South Africa has a climate belt of the Mediterranean type where the production of fine citrus fruits has expanded steadily since the 1930's. Some 4 million boxes of oranges, two thirds of the total production, are shipped each year, making citrus second to wool in South Africa's farm exports. Great Britain is the major market, with some shipments to Scandinavia and West Germany. The orange is equally successful in parts of Australia, but



Here the 30,000 lakes of Florida, chiefly central Florida, show their climatic influence. Grapefruit grows in same areas except none in Great Valley of California. ***U. S. Bureau of the Census***

the Australian orange has not as yet played much part in world trade.

In South America the greatest commercial production of citrus fruit occurs in Brazil. In 1939 it was estimated that Brazil had more than 20 million trees, predominantly orange, concentrated largely in the states of São Paulo, Rio de Janeiro, and Minas Gerais. Orange production had expanded rapidly to a peak of 35.7 million boxes in 1939, with exports of 5.6 million boxes mainly to Great Britain and Argentina. Since then Brazil's orange industry has been adversely affected first by the closing of the European market and then by a disease that destroyed a great number of trees. Production has declined somewhat and exports are less than half the prewar average, with Argentina as the major market.

Elsewhere in Latin America there has been some expansion of citrus production. In the oases of western Argentina and the Central Valley of Chile, production of lemons has tripled and that of oranges has increased considerably. Little fresh citrus is exported from these countries and Argentina is a substantial importer.

Old citrus areas of the Caribbean. Citrus fruits have long been grown in various islands of the West Indies and are cheap and abundant in the local markets. Cuba enjoyed a short-lived orange boom at the turn of the century when freezes heavily damaged the developing industry in Florida, but shipping costs and tariffs, especially tariffs, have prevented much competition with U. S. production. Since World War II, Great Britain has contracted for increased purchases of orange juice from Jamaica and other British dependencies in the Caribbean area.

Processed citrus products may be the basis for further commercial development, although there is some shipment of citrus, mostly to the United States. This area leads in the production of limes, which do best in a tropical climate. Mexico produces about half the world crop, with the West Indies and Florida supplying a quarter, and Egypt most of the remainder. The United States imports from 50,000 to 75,000 boxes a year from our southern neighbors, but a more important outlet for their surplus is lime juice and oil for food manufacturers in Europe and America.

The citrus industry in the United States. The United States is the only major citrus-producing country which also has a domestic market of first-rank importance. We produce about 40% of the orange and lemon and 90% of the grapefruit crops of the world—more than the entire Mediterranean Basin (see Table 9:1). The overwhelming proportion of this production is consumed within the United States. Exports of fresh citrus, mostly to Canada, amount to less than 5% of our production, in striking contrast to Mediterranean countries where citrus exports of from 50% to 80% of production are common.[12] Imports, which were important during the nineteenth century, have virtually disappeared.

Our acreage in citrus orchards has tripled since World War I, and the production of the various crops has increased even more. The rapid expansion of canning and freezing is a more recent development of great significance. Between 1935 and 1951 our production of all citrus crops more than doubled. But consumption of fresh fruit increased only 40%, while

[12] U. N., Food and Agriculture Organization, *Commodity Bulletin No. 19*, "Citrus and Dried Fruits," 1950, p. 28. Even if the shipments of processed citrus products are included, the proportion of U. S. exports to production is very low.

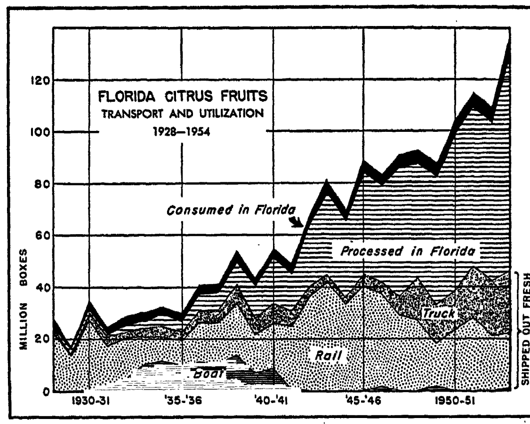
consumption of processed citrus products increased more than ten times. As a result, in the crop year 1951–52, 45% of our citrus crop was processed, 53% was consumed fresh, and 2% was not used.[18]

The development of citrus production in Florida. Although the orange and grapefruit were grown in Florida by the Spaniards more than three centuries ago, it was not until the building of railroads and the establishment of through-train service between Florida and the North in 1886 that citrus fruits became a commercial crop. The planting boom that followed the railroads spread also from Florida to the adjacent southern states. It is possible to grow good oranges throughout much of the Gulf region, but there is always the danger of a cold wave coming from the center of the continent. If not in rapid growth at the time, the orange tree can resist some frost, but the warmth and moisture of the Gulf region may make the tree grow rapidly at any time during the winter. As a result, freezes soon destroyed most of the commercial orange groves in Georgia, Alabama, Louisiana, and Mississippi.

Similarly the citrus groves along the St. Johns River in northeastern Florida were virtually wiped out by freezes in 1894 and 1899. Today more than 70% of the citrus acreage is located in the central part of the state on rolling uplands, with the advantage of air drainage and where the presence of more than 30,000 lakes tempers the occasional cold north wind and reduces the hazard of frost.

The remainder of the Florida citrus acreage is concentrated around Tampa Bay on the west coast and in the Indian River Valley on the east coast, where the warming influence of the sea is generally effective. Some of the growers keep oil heaters in their groves or have piles of wood ready to be ignited at the approach of a cold wave. In the central lake region orange groves line the highways as cornfields do in Illinois or Iowa.

Florida is also the leading producer of

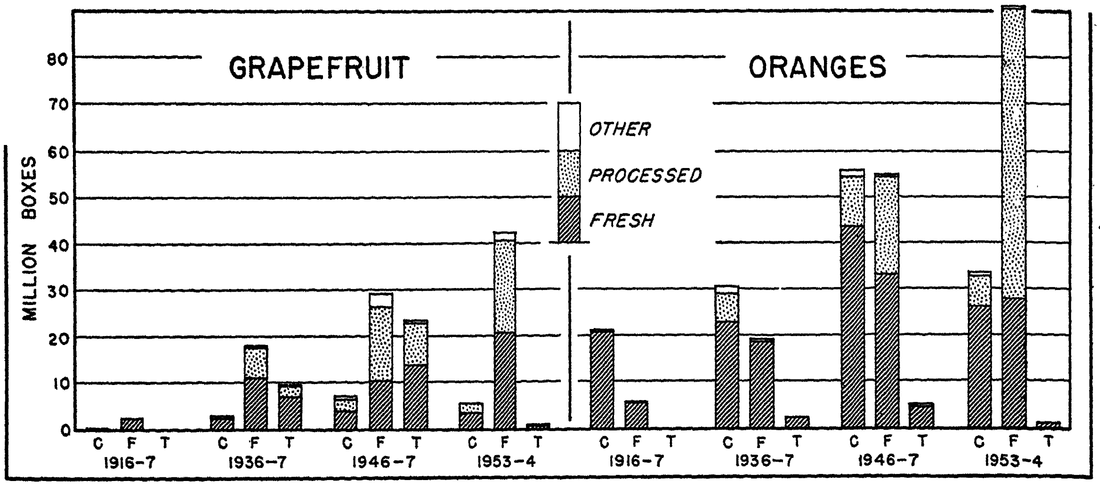


Two technological battles. Rail annihilates boat. Truck exceeds rail. The new juice devices eclipse all the others combined. Trucks carry large tonnage to New York and Chicago. Processing began with canned juice—200,000 gallons of frozen concentrate of 1945-46 zoomed to 65,500,000 gallons in 1953-54. In 1950 Dr. Sperti, the sunlamp man, discovered that ultraviolet rays check bacteriological change, and in some cities the milk man is now delivering quart containers of natural juice, 3 days from the tree, shipped in tank cars. *Florida State Marketing Bureau, "Annual Fruit and Vegetable Report, 1954"*

grapefruit, the 1953 crop of 42.1 million boxes being four fifths of the nation's supply. From 7 to 12 million cases of canned grapefruit segments and juice are marketed each year. Tangerines (5 million boxes in 1952) and other kid-glove varieties are grown all through the citrus belt. While Florida produces most of the nation's limes, lemon production has become virtually a California monopoly. Neither lemons nor limes meet with much favor in Florida, being delicate and easily frosted. California has a few small spots with very favorable climate.

Canned and frozen citrus products. The growing popularity of the small can of frozen, concentrated orange juice has had a tremendous impact upon the Florida producer. In 1940–41, 85% of the Florida crop was consumed fresh, largely in the North, and the balance was canned for single-strength juice. In 1953–54 only a third of the crop was con-

[18] USDA, Bureau of Agricultural Economics, *Agricultural Outlook Charts, 1954,* Oct. 1953, p. 73.



Regional history of two fruits since World War I. C—California, F—Florida, T—Texas. This rapid growth helps to explain the apple decline. The processing plant has taken Florida's great increase. Since 1947 Texas citrus area has suffered freezes and drought. California must irrigate. Florida depends on rain and has large areas of suitable land. ***U. S. Dept. Agriculture data***

sumed fresh (see Fig. 149), while 45% went to the frozen concentrate plant. During this period Florida has surpassed California in bearing acreage, and the 1952–53 crop of 72 million boxes represented 60% of the national total. Florida's dominance seems assured for some time, since 1951–52 estimates give Florida nearly 70,000 acres of young, non-bearing orange trees, while California has only 8000 acres.

Freezing is relatively unimportant for grapefruit products, although about half of Florida's crop is processed into canned grapefruit juice and sections. Florida clearly dominates the processed citrus industry, producing in recent years over four fifths of the various canned and frozen items with the exception of lemon juice.

The California citrus industry. Florida's misfortune in the 1890's proved to be California's advantage. The northern limit of the orange in Florida is about 30°N. Lat. while, in California, owing to the oceanic climate of the Pacific coast, the tree grows as far north as 39° in the northern part of the Great Valley. However, the region in which the industry has had nearly all its large development is south and west of the Coast Range in the Los Angeles-San Diego district of southern California.[14]

Southern California has a destructive freeze about once every 10 years. The historic freezes of 1913, 1937, and 1949 severely damaged from one third to one half of the crops in those years and caused loss of millions of dollars. A second freeze in 1950 damaged between 15% and 25% of the crop in Arizona and California.

California oranges are grown with the most perfect care on irrigated land of high value, the orchards often being valued at $2000 and more per acre. This very high land value has been largely due to the scarcity of water, and the continued growth of towns and cities in the Los Angeles area also results in semi-urban land valuations in parts of the citrus area.

Since irrigation is necessary for citrus production in California, great pains are taken to get and save water. Tunnels are sometimes dug back into the hillsides to strike the under-

[14] In 1951 there were 289,279 acres of commercial citrus orchards in California, of which 243,735 were in southern California, 43,314 in the southern part, and 2,230 in the northern part of the Great Valley. Three fourths of the state total was in oranges, one fifth in lemons, and most of the remainder in grapefruit. University of California, Agricultural Experiment Station, *Citrus Growing in California*, Extension Circular No. 426, Berkeley, 1953, p. 6.

ground flow; wells are dug, and pumps lift the water to the land where it is often carried in cement pipes and put around the base of each tree so that the smallest possible amount may make an acre prosperous. Today the citrus orchards of the Los Angeles Basin are receiving water conveyed by aqueduct tunnel and pump from the Colorado River 300 miles away. "The amount of irrigation water required varies from 18 acre-inches per acre near the coast to 36 or more acre-inches in the interior. As much as 6 acre-feet per acre are used in some desert plantings."[15]

Production costs in California are generally higher than in Florida, owing to the need for irrigation and for more protection from frost and wind damage. Consequently, California producers specialize more in the production of high-quality fruit for the fresh market (see Fig. 150). Although Los Angeles is now second only to New York City as a market for fresh fruit and vegetables, much California citrus is shipped to midwestern and eastern cities despite the high transportation costs. California also provides most of our exports of fresh citrus. In the 1952–53 season California produced 45 million boxes of oranges, 12 million boxes of lemons, and 3.4 million boxes of grapefruit. These totals represent 38% of the oranges, 6% of the grapefruit, and nearly all the lemons produced in the United States.

Adjacent Arizona has conditions similar to the desert sections of California. Irrigated citrus groves in the Salt River Valley produce about as many grapefruit as does California and a small amount of oranges (see Fig. 148).

The lower Rio Grande citrus area. Our third major citrus district, an irrigated area along the lower Rio Grande in Texas, has experienced a rapid rise and a catastrophic decline. Commercial shipments started in 1921. By 1946–47 Texas produced 5 million boxes of oranges and was second to Florida in grapefruit with a production of 23 million boxes, 40% of the national crop. Disastrous freezes in 1949 and 1951 not only brought production to low levels (see Fig. 150) but also heavily and permanently damaged the existing plantings. Drought, especially during 1952 and 1953, lowered the water level and made it impossible to irrigate some of the groves. Freezes and drought caused many groves to be removed, with some of the land being planted to vegetables and cotton. The estimated number of citrus trees dropped from 13 million in 1949 to 3.7 million in 1952.[16] Even if the industry revives we have here a striking and recent example of the problems inherent in the effort to produce these crops near their northern limit of cultivation and in the absence of long-time climatic records.

5. THE GRAPE AND WINE INDUSTRIES

History and requirements of the vine. The grape outranks all other fruits in literature, romance, intoxication, and in sober gustatory delights. These factors have combined with its importance in classic lands to make the grape the most celebrated of fruits—even back to the day when Noah relaxed after bringing his ark to port with its precious and varied cargo.

The chief requisite for the grape is a summer of considerable heat lasting into September. The vine sends its roots to great depth and can thus search out water in arid soil and will thrive in dry climates when most surrounding vegetation is brown and dead. Accordingly, the grape is at home upon the edge of the world's subtropic belt in each of the three continents of the Northern and Southern hemispheres. Too much moisture is detrimental, producing fungi that attack and destroy both the leaves and the fruit. Thus the monsoon climate of India, China, and Japan with its great summer rain makes extensive grape growing impossible, and our southern states follow suit.

Importance and difficulty of transplanting the industry. Grape growing and wine making reach their greatest importance as na-

[15] *Ibid.*, p. 18.

[16] Data from a letter, January 19, 1954, from P. A. Nicholson, Chief, Fruit Branch, USDA, Agricultural Marketing Service.

tional industry in France, Italy, and Spain—countries which produce about three fifths of the world's wine and have long dominated this industry. Other countries of importance in the Mediterranean area are Algeria, Portugal, and Yugoslavia, while the United States and Argentina are leaders in the New World. But the industry is hard to move.

In the first place it is an intensive industry requiring a dense population. Like a garden crop, the grape crop requires much labor. The yield is great, in France about 400 gallons of wine per acre. In the second place, expensive appliances and much labor are required for the fermentation of the juice into good wine, and great skill is required to get the desired flavors in the product. The best wines are sold by the name of the country or place producing them, as Burgundy, Madeira, Champagne, etc., and a long time is required to establish a reputation. Owing to soil influences, particular varieties of grapes and qualities of wine are often limited to narrow localities. Consequently, connoisseurs the world over look to the vineyards of the Old World for the particular wines and vintages of their choice. Lastly, the people of Mediterranean countries are the world's greatest wine drinkers. Most of the production is the inexpensive "natural beverage" wine, consumed within the year of its vintage as the daily drink of the great mass of the population. This geographic coincidence of long-established producing areas and dominant consuming markets guarantees the supremacy of the Mediterranean and western Europe in the world's grape and wine industry—barring some revolution in drinking habits elsewhere.[17]

The Italian wine industry. Italy depends more upon grape growing and wine than does any other nation. While her wine is not, unfortunately, so highly prized as that from some other countries, it nevertheless accounts for about one fifth of the value of Italy's agricultural production. The limestone hills and dry summer permit the grape to thrive better than most other crops, and grapes are grown in all parts of the country, although northern Italy is the more important producing area. Vineyards cover not less than 15,000 square miles, with additional crops planted on about three fourths of this.

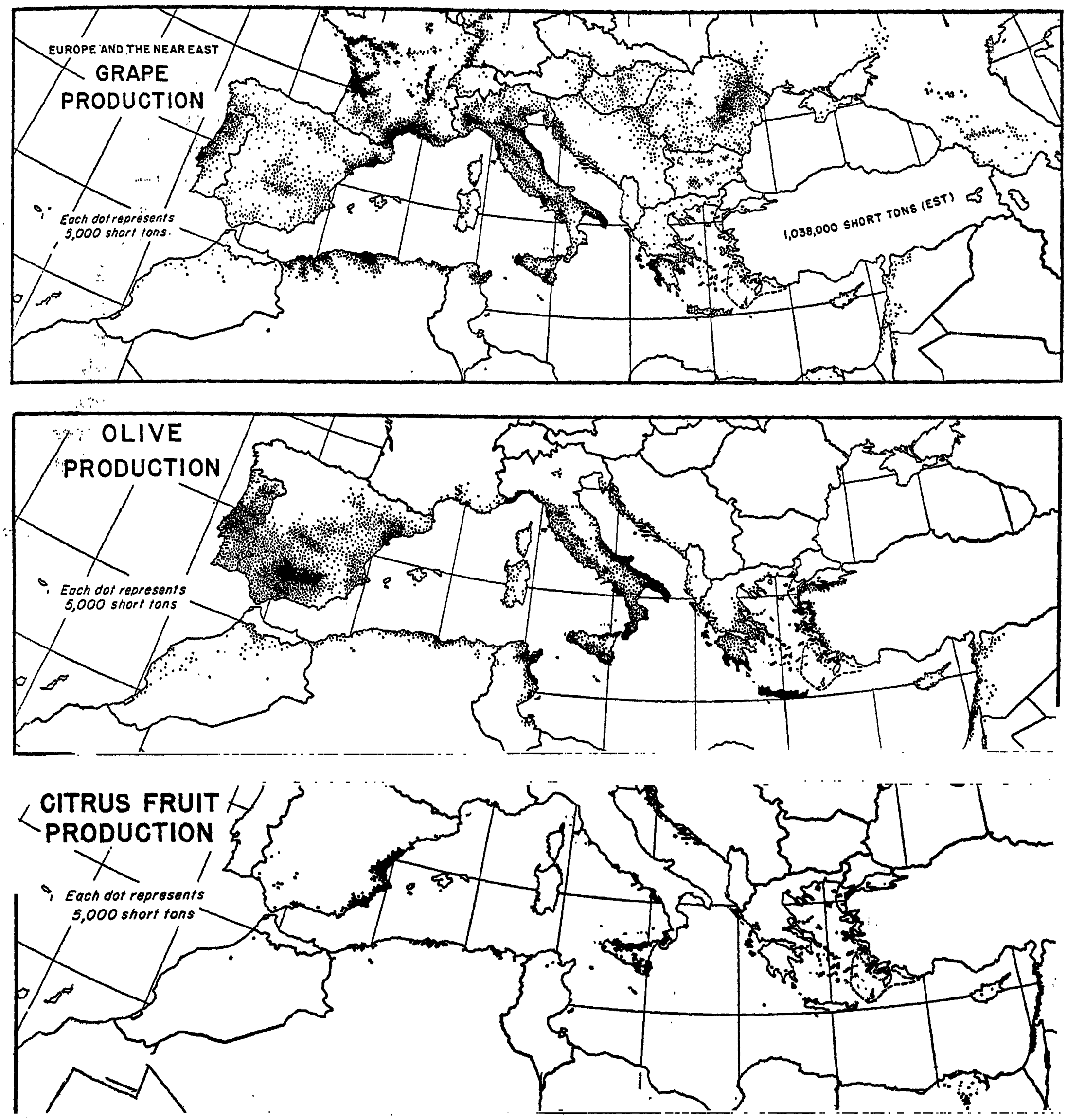
The land in grapes represents about one eighth of Italy's total area, and more than one fourth of all the cultivated land. These figures become more significant in comparison with the corn crop of the United States, which covers about one twentieth the area of the country. Italy has regained her prewar production of about 1 billion gallons a year, but the 1951 export of 25.8 million gallons was about one third below the prewar average.

French wine industry. France is the leader of wine-producing countries, and her people consume on the average at least 25 gallons of wine per capita per year. While the grape area (5700 square miles) is only one third that of Italy, the yield (1.3 billion gallons in 1952) is greater than Italy's, a measure of the superiority of French land, rainfall, and agricultural methods. France has a virtual monopoly on the production of really fine wines as a result of many favorable soil localities and, more importantly, the skill of the French wine producers. "Winemaking takes its place among the many 'specialty' occupations for which France is renowned,"[18] and provides the country's leading agricultural export.

Wine is produced in most of France except the northwest, where humidity and lack of sunshine do not favor the grape. The plain of Languedoc, along the Mediterranean coast from the Rhône west to the Pyrenees, specializes in the production of *vin ordinaire,* consumed in such large quantities by the

[17] Grape and wine are virtually synonymous. In the years 1945–49 the average world production of grapes was 31.5 million tons, of which 25.2 million was used for wine, 4.1 million for the table, and 2.2 million for raisins. Europe and the other Mediterranean countries produced 78% of the grapes and 83% of the wine. Only for raisin grapes was there greater production outside this area.

[18] See H. Ormsby, *France, a Regional and Economic Geography,* E. P. Dutton & Co., New York, 1950, pp. 418–424; citation on p. 424.



The frequent references to oil and wine in the Bible attest the antiquity of these industries. The hillside vineyards along the Moselle and the neighboring Rhine make the most northerly tip of vines in Europe. The North African extension is recent French influence.
The olive and citrus show the fear of frost. ***U. S. Department of Agriculture***

French. A second major area is in the Garonne Basin of southwestern France. Here, especially in the Gironde district near Bordeaux, is large-scale production of fine wines for export—Sauterne, Médoc, and Graves being well-known names. Some of the most famous French wines are produced in relatively small amounts near the northern limit of the grape, where climatic uncertainties require extreme care in cultivation. These include the districts along the Loire River, in the Rhine Valley, and the Champagne which reaches the Belgian boundary and marks the northern limit of profitable vine culture.

While French wines are consumed throughout the world wherever the people wish to drink the best of wine, the French themselves are large wine importers, taking practically

the entire crop of Algeria (which is one quarter as great as that of France), some from Italy, Spain, and Portugal. They sell their own high-priced wines and use the cheaper imported wines for home consumption, although some is re-exported. In 1951 France imported 267 million gallons with an average value of 55¢ per gallon and exported 49 million gallons valued at $1.30 per gallon.[19]

Spanish and Portuguese grape and wine industry. Spain, the third great wine-producing country of the world, is also a grape exporter, shipping (especially from Malaga and other southeastern ports) $4 to $5 million worth of grapes each year when business is good. Grapes are grown in many parts of Spain, but the most important areas and the source of wine for export are along the Mediterranean coast and also the plain of Andalusia in the southwest. In the late nineteenth century, wine made up one third of Spain's exports. Now it is but one of several leading exports, being surpassed in value by shipments of cotton textiles, oranges, and, sometimes, olive oil.

The best known of Spanish wines is the "sherry" which, since the time of Shakespeare, has been exported from Jerez de la Frontera, a town near Cadiz. (*Jerez* has been corrupted into *sherry.*) Portugal, which resembles Spain in people, resources, climate, and industry, has one twentieth of its total area in vineyards. With a total production generally below half that of Spain, Portugal's export of wine sometimes exceeds that of its neighbor. Port wine (derived from Oporto) is the leading brand. Spain and Portugal together produced 665 million gallons of wine and exported 47 million gallons in 1950.

Hillside grape growing in Europe. In the northern parts of the European grape belt the desired heat and sunshine can be obtained by planting the vineyards on the southward-sloping hillsides. In this way they are protected from the north winds and exposed, by the inclination, to the nearly direct rays of the sun; often, in addition, they get the reflected sunshine as from the surface of the Rhine, the Moselle, and the Swiss lakes. By this means Switzerland has become a wine producer, utilizing the slopes overlooking Lake Geneva and the other lakes, the Swiss wine output amounting to about 20 million gallons a year. Germany, with a production less than one twentieth that of France, is perhaps the best example of hillside grape growing. The most famous of the German districts are upon the steep south slopes that come down to the Rhine, and its tributaries, the Neckar and the Moselle.

The vineyards upon these riverside slopes prosper in latitudes where otherwise they would scarcely exist. Some of the Rhine terraces have been in grapes continuously for centuries, and so highly prized have certain brands of wine become that new terraces have been built from time to time in places so forbidding that a retaining wall had first to be built and earth carried up from the river bank (often by women) before the vines could be planted. These terraces, so steep that horses cannot be used, are cultivated entirely by hand, even to the carrying up of baskets of manure, strapped upon the backs of men and women.

Owing to the scarcity of land, terrace vineyards are common on Italian hills and mountains. Nearly 200 terraces, one above the other, may be seen on the southern slope of the Apennines near Lucca.

Other wine regions. Yugoslavia and Greece are among the lesser producers who often have a modest surplus for export. Wine is produced in all countries around the eastern Mediterranean, and the warm oases of western and central Asia often produce surprisingly good wines for local consumption. Russia's grape and wine areas are in her subtropical sections, especially the Caucasus and

[19] U. S. Department of Commerce, *Foreign Commerce Yearbook, 1951,* Washington, 1953, pp. 383, 385. Algeria is far ahead as an exporter on a quantity basis with an export of 257 million gallons (1951), over twice the combined export of France, Italy, Spain, and Portugal.

Crimea, while Bulgaria and Rumania also have some production.

The wine industry in new countries. There have been many attempts to establish a wine industry in other countries, but for reasons already stated the progress has been slow. Large areas in North and South America, North and South Africa, Australia, and Asia are probably as well suited to wine making as is Europe, and Europeans have established vineyards and wineries, often in the early stages of settlement. But these areas lack the mass of wine-drinking population which assures the dominance of the Europe-Mediterranean area. The growth of sheep, cattle, and grains springs up in a new country in a short time, and Europe has for decades depended on them for such imports. Wine, however, flows in the opposite direction, despite the recent rapid expansion of the grape industry in several new countries.[20]

Australia. The grape vine came to Australia with the early settlers, but today there are only a modest 135,000 acres in vineyards, 90% of which is in the Mediterranean-climate areas of South Australia, Victoria, and New South Wales. A small wine production (40 million gallons in 1952) comes mostly from unirrigated vineyards in the Adelaide plains. But surplus is a problem,[21] and subsidies support the export of a few million gallons to Britain and the Commonwealth.

Australia is unique among grape-producing countries in that more grapes are used for raisins and currants than for wine. Most of these grow on irrigated land, watered by the Murray River, with the state of South Australia a poor second to Victoria in production. The currant is a highly specialized type of vine, long restricted to certain parts of Greece where it occupies a major place in agriculture and export trade. Australia's production of some 17,000 tons is about a quarter as large as that of Greece and, with 1000 tons from South Africa, these supply the entire world commercial crop.

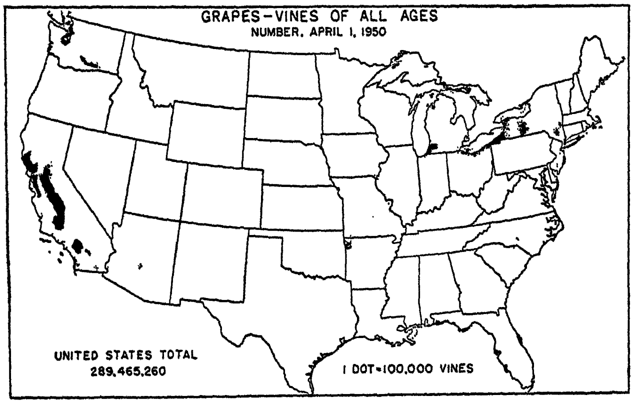
South Africa. South Africa seems to have, in the western part of Cape Colony near Capetown, just the right conditions of soil, sunshine, and moisture to make it one of the best grape-growing regions in the world. The Dutch settlers succeeded well with French and Rhenish vines, and in 1822 this region sent more wine to England than did France. The fungus and insect pests of the nineteenth century, however, retarded the industry. Present-day production and export are about a third larger than those of Australia. The ripening of the fruit in the springtime, when we have nothing but expensive hothouse products in northern latitudes, causes the export of some fine grapes to Great Britain, along with the citrus and other fruits previously mentioned. South Africa exports over half her production of fresh grapes and takes fifth place, after the "big three" and the United States, in this small export trade.

South America. South America has its grape districts upon the edges of the desert belt which cuts diagonally across the continent from northern Chile to southern Argentina, between the eastern rain belt of the trade winds and the western rain belt of the westerlies. Chile is a large consumer of wine, and the local production often amounts to about 18 gallons per capita. This is grown on an area half as large as the German vineyard area and located in the northern part of the great Central Valley of Chile, a region supporting most of the agriculture and population of that country and much resembling the Great Valley of California. Near Santiago there is a splendid plain given over to intensive culture by irrigation and to the growth of grapes which are made into a wine of local fame. Chile has a small export of wine mostly going to Western Hemisphere countries.

In Argentina the chief grape and fruit dis-

[20] On a quantitative basis, however, the shipments *from* Europe are a relatively small portion of the world's wine trade. In 1951 Europe herself accounted for 83% of the world's wine imports.

[21] The 8 million Australians sip less than 2 gallons of wine while imbibing 18 gallons of beer per person per year.



The grape loves the shore lands, even a group of long narrow lakes in New York, but shuns the heat and humidity of the Southeast. ***U. S. Bureau of the Census***

tricts are dominated by French wine growers in the irrigated settlements of Mendoza and San Juan, watered by snow-fed streams from the nearby Andes and separated from the agricultural plains of the east by some hundreds of miles of arid sheep and cattle ranges. In both Argentina and Chile, 90% of the grape crop is crushed for wine. Argentina's wine production, all of which is consumed within the country, has increased rapidly and averages 298 million gallons a year (1948–52), four times that of Chile.

Grape growing in the eastern United States. When the European colonists landed upon the shores of the United States and stocked their gardens with the plants and trees of Europe they were pained to find that all the grapevines promptly died, killed by fungi native to America but not found in Europe. The fungi attacked the roots. By grafting European tops to American roots this difficulty was overcome, and European varieties can be grown in the United States. For table grapes our native stock has been used by plant breeders who have evolved a number of varieties of edible grapes, their names, Concord, Clinton, Niagara, Delaware, Agawam, Catawba, Early Ohio, etc., showing their American origin. These are slip-skin varieties.

The grape is widely grown throughout the eastern and southern parts of the country as a garden crop, but the cold waves of the continental climate with their late spring frosts seem to make it uncertain as a money crop except in localities where water bodies give frost protection. Consequently, the eastern grape belt lies close to the shores of Lake Michigan and Lake Erie, to a lesser extent to those of Lake Ontario, and to the five slender north and south lakes of New York, called the Finger Lakes. The vineyards of the Finger Lake district are upon the southern and western slopes of the hills along the eastern shores of the lakes, the prevalent west winds blowing across the waters in spring giving the desired temperature. The fact that New York state possesses the Finger Lakes and touches the two Great Lakes, Ontario and Erie, gives it leadership in eastern grape growing. Michigan, Ohio, and Pennsylvania, with smaller lake-shore grape areas (see Fig. 156), follow New York among the eastern states. Canada's main grape area rims the lee shore of Lake Ontario.

California, our leading grape grower. Although the European grape failed in the eastern United States it has succeeded remarkably in California, where it was introduced by the Franciscan fathers during the latter half of the eighteenth century. The earliest variety, now generally known as the Mission, was probably brought over from Europe in the time of Cortez. It was admirably adapted to the purpose of the missions, for besides being a good table grape, which kept well and was not too sensitive for primitive methods of handling, it could be used for the making of sweet wine. Even after the American occupation of California, it was for many years the only variety in use. While well adapted to the climate and a prolific bearer, it was susceptible to the inroads of the phylloxera, a great insect pest of the grape vine. Here, as in many grape areas throughout the world, the industry was saved from complete destruction during the nineteenth century by grafting European varieties of vine onto the roots of varieties from eastern United States, the home of phylloxera, which were

therefore immune to this scourge of the grape.

California, with 80% of the grape vines produces 80% to 90% of our grapes. The San Joaquin Valley, the most important producing area is comparatively level, in marked contrast with the vineyards of Italy, Germany, and Switzerland, and the deep valley soil with irrigation gives a yield per acre greater than any other part of the world. In most of Mediterranean Europe the vineyards are not irrigated, the better land and available water being required for food crops to feed the dense population. All types of grapes are grown in California, but the hot, dry summer of the San Joaquin Valley especially favors the production of raisin and table grapes. A second type of producing area, emphasizing wine grapes, is in the inland portions of the coastal valleys in the central part of the state, where vineyards are largely not irrigated. Southern California is the state's third producing area. Elsewhere among the Pacific states the only other important grape area is in the dry Yakima Valley, where irrigated vineyards give Washington a grape crop about as large as those of Ohio or Pennsylvania.

Since World War II, the United States has displaced Spain as the third largest producer of grapes and wine.[22] The increase in wine production since the abandonment of prohibition in 1933 has been phenomenal. American wines, chiefly from California but also from eastern vineyards, now rival all but the most renowned European wines in quality. Nearly half of our record grape production of 3.2 million tons (1952) was crushed, mainly for wine. However, the major importance of our raisin industry, together with our large consumption of fresh grapes, make production for raisin and table more important in the American grape industry than in the European.

[22] Annual Average Production

	Grapes (thousands of tons)		Wine (millions of gallons)	
	1935–39	1948–52	1935–39	1948–52
United States	2,444	2,985	193	417
Spain	3,338	2,633	491	375

Source: USDA, *Foreign Crops and Markets,* December 15, 1952. pp. 548, 552.

6. DRIED FRUITS

The shifting of the industry to the lands with a dry summer. Before the coming of steam transportation, when each locality lived to a great extent upon the local resources and the farmer's family lived almost entirely upon the products of the home farm, the drying of fruits on shed roof, garden fence, and kitchen drier in humid America and Europe was almost as common as their production. With improved transport and production methods, there had developed a large traffic in dried fruits from those parts of the world having unusually favorable conditions for their production. These are found in the sunny and rainless summer of countries having Mediterranean or Desert types of climate, whose dates, prunes, raisins, and figs can be dried and the surplus shipped to markets in less sunny climes (see Table 9:2).

TABLE 9:2. Dried Fruit, Production and Export, United States and Selected Foreign Countries,[a] 1952
(thousands of long tons)

Fruit	Production Foreign	Production U. S.	Exports U. S.	Exports Foreign
Dates	980	17	..	303
Prunes	19	123	45	18
Figs	144	24	1	49
Raisins and currants	309	263[b]	85[b]	216
Other dried fruits[c]	13	25	3	9

a Total for foreign countries listed in sources.
b No production or export of currants listed for U. S.
c Apricots, peaches, apples, pears.
Sources: Commonwealth Economic Committee, *Fruit, A Summary of Figures of Production and Trade Relating to Fresh, Canned and Dried Fruit and Wine,* London, 1953, pp. 112–132. Date production from USDA, *Agricultural Statistics, 1953,* p. 215.

Note how the date is king of the dried fruits, but relatively unimportant in the United States. Our position as a producer and exporter of dried fruits depends on California's prunes and raisins.

Competition of California with South Europe. In almost any grocery store or supermarket in the United States today, boxes and cellophane bags of these dried fruits may be seen, and the names and addresses stamped on them will show that they have come into these American communities from many distant parts of the world. California names predominate, however, although 50 years ago the

labels usually showed South European names. California, with large-scale, mechanized methods and artificial driers (despite her vaunted sunshine), now supplies almost the entire home market with a large surplus for export. In contrast to the large and increasing use of canned and frozen fruits and vegetables, the per-capita consumption of dried fruits (4.3 lbs., 1952) is almost exactly what it was in 1909. Nevertheless, the United States produces about a half million tons of dried fruit each year, 80% of which consists of raisins and prunes.

The prune. One of the first California dried-fruit exports to compete with Europe was the prune, a dried plum which has long been exported from several Mediterranean districts, chiefly the Balkan countries and France. California accounts for over three fourths of the world prune crop, but there has been a slight downward trend in both area and production since the early 1930's. Most of the crop is processed in dehydrators instead of being sun-dried. These machines dry prunes and apricots in 10 to 14 hours, whereas sun-drying takes 10 to 20 days and the fruit loses more weight due to fermentation. There is also less labor cost in artificial drying. With so large a share of world production, the United States dominates the export trade for which western Europe is the major market. Our exports averaged 71,000 tons (1947–51), somewhat below prewar but still over a third of our crop.

The raisin. The raisin has for centuries been an important crop and export from countries around the Mediterranean Basin. Sultana raisins, produced from a seedless variety of grape, are grown along the eastern Mediterranean, the chief center being Smyrna (Ismir), with other centers of production upon islands in the Aegean Sea and, to a less extent, in Greece itself. Turkey was long the world's leading exporter with Greece, Iran, and Spain of lesser importance.

This Old World industry has been transplanted to the Great Valley of California with such success that the city of Fresno is now known in many countries as a raisin center. Vineyards of raisin grapes cover the land for miles around, making Fresno County the second richest agricultural county in the United States. The raisin grower dries his own grapes in his own vineyard beside the vines, then hauls them to the raisin plant where machinery does all the rest of the work until the seeded raisins are packed into a variety of boxes for shipment. Men worked for years to develop a seeding machine that takes the raisins and, by a process similar to that of the cotton gin, puts the raisins in one place and the seeds in another.

Before 1890 the United States imported an average of 19,000 tons of raisins a year, which decreased rapidly with the growth of raisin production in California. We now produce about half the world crop and, since World War II, have been the leading exporting country, although total shipments from Mediterranean countries exceed our own (see Table 9:2).

The fig. Commercially the fig is a subtropical product. The tree is hardier than the orange, thrives over most of southern Europe and even survives in sheltered places in England, Texas, and many parts of the southern United States. Production of the fruit began late in the nineteenth century, following a long and expensive effort to acclimatize a Mediterranean insect necessary for fertilization of the fig blossom. California production of around 30,000 tons of dried figs each year (100,000 tons, fresh basis) is nearly sufficient for our home market, but figs are not yet an export crop, partly because of the laborious process involved in drying.

The Mediterranean area, where figs are widely used as local food and where labor is cheap, dominates both production and export. Turkey, with an important district around Smyrna, is usually the leading exporter, particularly of quality figs. Greece, usually in second place, recently has been surpassed by Algeria, the one country where there has been a substantial increase over prewar production.

Young date trees, Saudi Arabia: heavy bunches of fruit. Dates, the most nutritious fruit. Tree is full grown but will get much taller as leaves grow only at top. ***Standard Oil Co. (N. J.)***

The importance of the date in desert countries. The date is the most important of dried fruits with a commercial production exceeding that for figs, prunes, and raisins combined (see Table 9:2), and with additional uncounted thousands of tons consumed locally. More nutritious than beef, it is the bread of the desert and sometimes used for stock feed. Because rain prevents the fertilization of its flower and the ripening of its fruit, the date palm is called the tree of the desert. But it also requires much water, and so is a tree of desert oases in North Africa and Southwest Asia, the major producing areas.

Underground sources of water occasionally reach the surface in the Sahara Desert, either by natural flow or by pumping, and create most fertile oases. These are carefully cultivated and support a surprisingly dense population. Their scattered locations make possible the caravan and motor routes which cross this great desert from oasis to oasis. Millions of date trees yield the chief crop, both supply crop and money crop, of all this region. A railroad through the Atlas Mountains connects the Saharan oases of Biskra, Touggourt, and El Oued with the Mediterranean ports and is one of the few lines in Algeria to show a profit.[23] Its main traffic is dates, grown in these oases and also brought to the railheads by caravan from other oases. Algeria is the leading African exporter, but production in densely populated Egypt is several times as great.

Iraq, however, is the leading producer and also provides about two thirds of the world's

[23] Benjamin E. Thomas, "The Railways of French North Africa," *Economic Geography,* April 1953, pp. 95–106. Good crops of apricots and vegetables grow beneath open-topped date trees.

export of this nutritious fruit. About half Iraq's production, and most of that from neighboring Iran, comes from a nearly continuous strip of irrigated land 1 to 2 miles wide along each bank of the Shatt-el-Arab, a river formed by the junction of the Tigris and Euphrates about 100 miles from the Persian Gulf. Smaller districts lie along both these rivers and in the desert oases of southern Iraq. The combination of good water supply and soil, warm winters, and easy export through the port of Basra on the Shatt-el-Arab has been the basis for Iraq's dominance in date export—most of which goes to western Europe and the United States.

In the United States, dates are grown in the irrigated areas along the lower Colorado River ("The American Egypt"), where climatic conditions resemble those of the Old World date areas. Our prewar production has more than tripled to an average of 16,000 tons per year (1948–52), but imports generally exceed our domestic crop which is only about one twentieth as large as Iraq's. We lack the mass market provided by the poverty-stricken oases dwellers of western Asia and North Africa. So the American growers concentrate on the very finest grades, which are put up in attractive packages and are sold for several times the price of the cheap bulk dates shipped in from the Persian Gulf.

Each continent has its Mediterranean fruit district. Each continent has its regions of Mediterranean climate with its winter rain, summer drought, irrigation, and nearby desert. (See colored map.) These conditions favor not only dried fruits but also the grape, citrus fruits, and some deciduous fruits—especially the peach. Therefore these regions are important for a variety of fruits. The dominant region is the Mediterranean Basin-Persian Gulf area with its long history, dense population clusters, intensive agriculture, and nearby European market. California, a comparative newcomer, has developed major importance and substantial world trade aided by American technology and the huge North American market.

The Southern Hemisphere areas are at a disadvantage because of their distance from the major European and American markets, coupled with the relatively small internal demand in the respective countries. Nevertheless competition is increasing as these countries become better developed. Dried fruits, which stand shipment better than fresh and are more concentrated than canned, provide export possibilities in addition to the off-season shipment of various fresh fruits.

In southern Australia for example, the Murray River supplies irrigation water for 150,000 acres of vineyards and orchards under the same kind of dry climate that prevails in California, Spain, and the Near East. The outlet for dried fruit (peaches, apricots, raisins, and currants) is about equally divided between the Australian and export markets. Particularly important are shipments to Great Britain and Canada, where they compete with the products of the Mediterranean countries and California.

South Africa has an increasing dried-fruit industry, the principal fruits being raisins, prunes, peaches, apricots, and figs. Chile has her "California" on the plains and irrigated fields near Valparaiso and Santiago. Over the Andes are the foothill settlements of San Juan and Mendoza in Argentina which are somewhat comparable to the lower Colorado Valley, producing raisins, dried fruit, and wine for that country.

7. THE CANNING AND FREEZING OF FRUITS AND VEGETABLES

The canning process and its service to mankind. The drying of foods is probably older than agriculture, but canning, a nineteenth-century development, has been a greater boon to mankind. In 1809 a Frenchman named Appert was awarded a prize, offered fifteen years earlier by his government, for an improved method of preserving foods. Appert had heated food placed in glass bottles that were hermetically sealed. Although not fully understood for decades, the principle of modern canning had been established—heat to de-

stroy bacteria and an air-tight container to prevent recontamination. Considerable success was soon achieved in Europe and America in canning foods in bottles and cans,[24] but it was not until the Civil War that the method was known and accepted by large numbers of people.

As years passed, costs have been reduced and quality improved by such technical developments as the pressure cooker (1874) and the cylindrical can with the crimped-on lid, which replaced the small-mouth can with the soldered lid about 1900, as well as continuous improvements in machine processing of fruits and vegetables. Today the industry is large, mechanized, and thoroughly established as a source of food supply for the masses. Between 1909 and 1951 the per-capita consumption of canned vegetables in the United States increased from 14.5 to 42.3 pounds, while that of canned fruit and juices increased from 3.0 to 33.5 pounds.

Revolution of agriculture by canning. Canning has revolutionized agriculture in many localities. Although the early development of rail and steamboat transport made it possible to ship perishable products considerable distances, it was not until the development of canning that a world market was available to the producers of many fruits and vegetables. The distribution of these crops now depends, not upon a nearby market, but upon environmental and economic conditions which make certain localities best able to produce certain products.

Commercial canning and preserving have also revolutionized food consumption. City people the world over enjoy a greater variety of food throughout the year. In more isolated localities the workers in a paper mill in the woods of Maine may now eat the tomatoes of Maryland, the peas of Washington, the cherries and peaches of California. The same is true of the uranium miner in arctic Canada, the copper miner of the high Andes, and the plantation worker in the equatorial lowlands.

Canning, more than any other invention since the introduction of steam, has made possible the building up of towns and communities beyond the bounds of varied production.

The extent of the industry. Practically all classes of food—fruits, vegetables, soups, fish, meat, and even nuts, bread, and pudding—are now preserved by canning. Commercial vegetables were harvested from 3.8 million acres in the United States in 1952 with the produce from 1.8 million acres going to the processing plant. Among the canned vegetables, tomatoes are by far the most important, followed by peas, corn, and beans. Among the canned fruits, citrus juices, peaches, and grapefruit are far ahead of salad fruit, pears, and apples. In 1947 there were 3826 manufacturing plants in the "canning, preserving, and freezing" industry which employed 200,000 persons and added over $900 million to the value of their raw materials.

Establishments of this type must be located close to their source of supply because fresh fruits and vegetables are perishable and also because the canning process makes them less bulky and more easy to transport. The canning industry is, therefore, a rural or small-town industry in which the individual plant is generally small and often specialized. Owing to the seasonable nature of the work, the labor is nearly all done in the summertime and often by transients who flock in from nearby cities for temporary residence of a few weeks or months. Although widely scattered, the canning industry in the United States has three distinct belts showing greater development than other regions, each of which is also important in the commercial production of fruit and vegetables (see Fig. 126).

The Atlantic Plain. The first of these regions to develop the industry was the Atlantic

[24] Canned foods were used by the military and explorers in the early nineteenth century. Two tins—one of beef, one of pea soup—taken to the Arctic in 1824 were found to be in good condition when recovered and eaten 87 years later. National Canners Association, *The Canning Industry*, Washington, 1952, pp. 5–7.

Plain. Maryland is the center and most important part of the Atlantic Plain canning district, which extends from North Carolina to New York. This section has become important for the same reason that made it important in the shipment of truck crops to the city markets, namely, the sandy soil which is exceptionally suited to vegetables and is not well adapted to the growth of other agricultural staples, especially wheat and grass.

Maryland is the leading state, canning on an average one quarter of our tomatoes and large quantities of beans and other vegetables. Baltimore was the only important big city center of canning in the United States, but more canneries are now located in the Philadelphia metropolitan area, especially on the New Jersey side of the Delaware in Camden. These draw their supplies from the specialized truck-farming area of southern New Jersey as well as from fruit and vegetable producers in nearby Pennsylvania.

The sandy southern part of Delaware gives that state an importance in the canning industry that is quite disproportionate to its small area. Maryland and Delaware are important also because they are large peach- and pear-growing states due to the protecting influence of the waters of Chesapeake Bay.

New York, New England, and the Lake region. New York, which is both a great agricultural state and a fruit grower, is the center of the northeastern belt, a region with great diversity of canned products. Most of the canneries are located in the western part of the state, convenient to the lake shores with their production of fruits and many vegetables, especially beans, cabbages, and peas. Similar relationships are found in the other lake-shore fruit and vegetable areas of Ohio, Michigan, and Wisconsin.

Sweet corn does well in the more northern states where summers are too cool and short to ripen the corn grain. Corn canning first developed in Maine, but three fourths of the pack now comes from the states along the northern margin of the Corn Belt, Wisconsin, Minnesota, and Illinois being the leaders.

The somewhat cool summer that makes of parts of New York, Michigan, and Wisconsin second-class field-corn producers, makes them first-class growers of peas, Wisconsin producing over one third of the annual pack. If the same factory can lengthen its season by canning several kinds of fruits and vegetables, it is a great advantage through the better utilization of the plant. Thus a plant at Janesville, Wis., begins its season in June with peas and ends it late in autumn with sauerkraut.

Many other fruit and vegetable crops move to the canneries of the northeast. Some are highly localized (cranberries in eastern Massachusetts); others are produced in several states (cucumbers for pickles and cabbage for kraut). These, together with the great bulk of tomatoes, corn, beans, and peas, make the northeastern area from Maine and Virginia to Minnesota and Iowa the country's most important canning district, including, as it does, the coastal plain and lake-shore fruit- and vegetable-producing regions.

The Pacific Coast. California, however, is the most important single canning state. It has become important through the combined influence of climate (excellent for the growth of fruits and vegetables) and the great distance from eastern markets, which makes it possible to ship in the fresh condition only an uncertain fraction—and that the most perfect—of the total crop. California cans nearly all the apricots and peaches, and the largest share of other fruits except apples and citrus. It is usually the leading state in tomatoes, spinach, and asparagus and also cans large quantities of several other vegetables.

The canning industry also has large possibilities in the other Pacific Coast states. The Willamette-Puget Sound valleys of Oregon and Washington have a damper, cooler summer than California and for that reason are producing and canning large quantities of berries, small fruits, and green beans. Peas from irrigated land in eastern Washington and Oregon makes these states second to Wisconsin in canned peas.

Outside the three major areas are other canning districts of national importance for particular products. Most important are the citrus fruit and vegetable canneries of southern Texas and Florida.

The possibility of increased production and of overproduction. The possibilities of increase in the production of fruits, vegetables, and canned goods in the United States are very great. If, for example, U. S. farmers could be assured 25¢ a peck for tomatoes at their farms for the next 10 years, it is probable that their production would be increased tenfold. Tomatoes are now commonly grown for less than that price, and occasionally the crops are so great that the factories cannot handle them and the tomatoes rot upon the ground by the hundreds of tons. The same thing is true of many other vegetables, including potatoes. This is a great deterrent to industry—almost the major problem of American agriculture.

Even with the aid of the outlet afforded by canning, the small fruits and vegetables yield so enormously that overproduction, with its glutted markets and frequent losses, is a factor that, like frost, is ever in the mind of the producer and almost annually visits each locality of varied production.

Foreign trade in canned fruits and vegetables. Canned fruits and vegetables are an important export from the United States to Great Britain and many other countries. England herself is an important manufacturer of preserved fruits—preserves being fruits so rich in sugar that they will keep without sealing. British jams and marmalades, made from fruits grown at home and also imported, are widely exported especially to the Commonwealth and are extensively consumed in Britain, where bread and jam is a favorite article of diet.

The possibilities of the production of canned fruits in the tropics are much greater even than that of canned vegetables in the United States, although little has as yet been done in this direction. Pineapples grown largely by Chinese and Japanese labor on the fertile lava slopes of the Hawaiian Islands go mostly to canning factories. The export demand for Hawaiian canned pineapple has made the industry second in value to sugar. The product is widely distributed throughout the United States, where is competes with imports from Cuba and Puerto Rico. In the Strait Settlements, at and near Singapore, canned pineapples are produced by Chinese labor and exported largely to Europe.

Frozen fruit and vegetables. Freezing has for decades been a method of preserving meats, but it has become important for fruits and vegetables only with the perfection of quick-freezing methods which much more nearly preserve the fresh taste and form of foods than does canning. Consequently, though still small in comparison with the canning industry, the frozen pack has increased more rapidly. Per-capita consumption has jumped from less than 1 pound in 1937 to 6.5 pounds of frozen fruit and 5.1 pounds of frozen vegetables in 1952. In the latter year, nearly 900 million pounds of frozen vegetables were produced, almost half of which were peas and beans. An equal amount of fruit was frozen, nearly half being citrus juices—a development which has had major impact on Florida orange production as already noted. More berries were frozen (230 million pounds) than were canned, and these were followed by cherries and peaches.

The frozen fruit and vegetable industry is primarily an American phenomenon, since the product must be transported and retailed at low temperatures before reaching its final storage place in the freezing compartment of the electric refrigerator or food locker of the American housewife.

10· The Beet-sugar and Cane-sugar Industries

Universal demand. Is there any other food as widely liked and so widely used as is sugar? There are hosts of vegetarians, but the antisugarites have not yet appeared, except unwillingly by order of the physician. Our children, our pets, and our domestic animals alike beg for it. But the general and heavy use of sugar among temperate-zone people is recent. In fact, for centuries honey was more important than sugar for the people of Europe. In 1589 a pound of sugar cost as much as a quarter of veal. In 1700, 50,000 tons per year were used in all countries of Europe. At the present time that quantity lasts the United States about 2½ days. There was a sevenfold increase in the world's commerce in sugar between 1815 and 1915, and commercial production has again doubled since World War I.

The growth of population and the increase in per-capita consumption, especially in the more advanced countries,[1] have created the demand for this expanding supply. Much sugar is used in the manufacture of candy and cake, soft drinks and ice cream, and in the sweetening of tea and coffee—luxury items which people in America and western Europe are fortunate enough to regard as necessities. North America and Europe therefore constitute the major market for commercial sugar. At the other extreme are the millions in eastern and southern Asia who consume less than 10 pounds per person (1951).

Race between sugar cane and sugar beet. Two plants have been the major contributors to this expanding industry despite the fact that many plants store sugar.[2] In the bowl and in the test tube cane sugar cannot be distinguished from beet sugar. But their origins are vastly different both in terms of area and systems of production. Sugar cane is a crop of the moist tropical lowlands, where it is usually grown as a single crop, often on plantations. The sugar beet is grown in the cooler midlatitudes, especially in Europe, where it is part of an intensive and diversified agriculture.

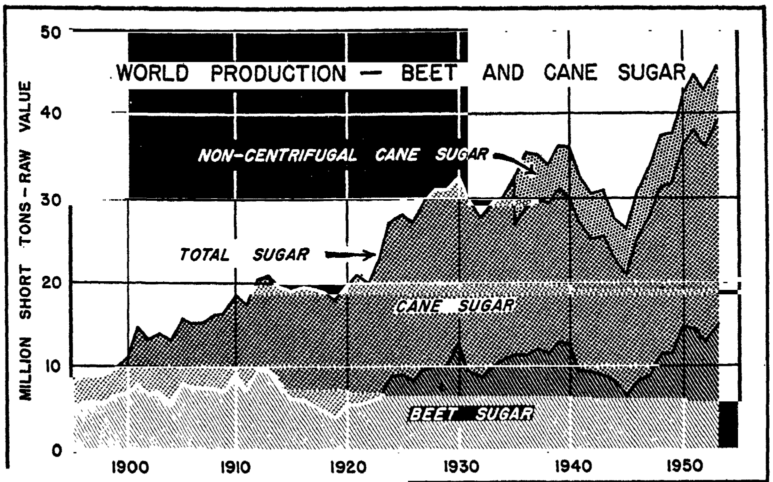
[1] Sugar Consumption (pounds per capita)

	1900	1937	1951
United States	73[a]	96	97
United Kingdom	73	91	84
Germany	30	53	62[b]
Holland	26	56	79
France	26	53	55

[a] 1909.
[b] West Germany, 1950.
Source: U. N., F. A. O., *Commodity Bulletin No. 22, Sugar,* 1952, pp. 87–98.

[2] All fruits have some sugar, the grape especially. Root crops, such as beets, carrots, and parsnips, hoard sugar to make their heavy top, blossom, and seed. Corn and sorghum, distant relatives of sugar cane, are minor sources for sugar and syrup, as are tropical palms of various sorts and the sugar maple in northern latitudes.

Compare total amount and relative shares 1895 and 1953. Note World Wars and beet. Centrifugal process in large mills sends sugar to world market. Noncentrifugal, brown and full of vitamins, is grown and used locally, especially in India. Raw Value means unrefined. *U. S. Department of Agriculture data*



Although the tropics and the midlatitudes compete in the production of various vegetable oils, starches, and fibers, sugar is unique in that an identical product comes from the two zones. If this interzonal competition were to be decided purely on the basis of cost, the cheaper cane sugar would virtually displace that from the beet. But for a century and a half this has not been the case. For various reasons governments have stimulated, subsidized, and protected the beet-sugar industry. Comparable assistance has been extended to the cane-sugar producers until it has been estimated that three fourths of the world sugar output receives some protection or preference.[3]

Political considerations thus play a major role in the economic geography of sugar and are vital to the continuance of beet-sugar production in most areas and cane-sugar production in some. So important has the sugar beet become to the economy of the producing areas that there is little likelihood of its abandonment, and the rivalry between the two sugars will continue for the foreseeable future.

1. THE BEET-SUGAR INDUSTRY

Late development. The beet-sugar industry is a nineteenth-century development. Its origin dates from the Napoleonic wars, when commercial blockades cut off France and often the rest of Europe from the cane-sugar supply of tropic colonies—largely British. At the order of Napoleon, French scientists examined hundreds of plants in the search for a promising sugar supply. Among them the grape and the beet were most seriously considered because of their high content of sugar, but industrial effort centered itself upon the beet, which the Germans first used in 1799. In 1806 the French government offered a bounty for beet-sugar production, and in 1811 Napoleon ordered 80,000 acres of beets to be grown for sugar. Only one sugar factory survived the Napoleonic wars and the renewed competition of cane, but the industry lingered along until finally by the middle of the nineteenth century it had become firmly established.

Beet sugar and science. The beet-sugar industry affords us one of the best examples of the service that science renders to man. In 1836 it took 18 pounds of beets to make 1 pound of sugar; in 1882 about 10 pounds sufficed; in 1924 about 7 pounds, and at the present time 5 pounds or less—a remarkable achievement in agricultural efficiency.

This great improvement has been brought about chiefly in Germany, where trained scientists devoted their whole time to improving the sugar content of the beets. Samples were

[3] C. J. Robertson, "Geographical Trends in Sugar Production," *Geographical Review*, January 1932, pp. 120–130.

Ever since beets began to yield sugar, men, women, and children on their knees, have thinned and weeded the little plants. ***U. S. Department of Agriculture***

cut from the most promising roots and tested; the best beets only were saved to produce seed the next year, and so on for generation after generation, always selecting the best. This process of systematic selection has, within the lifespan of man, trebled the sugar content of beets, and, along with improvements in the per-acre yield of beets and the process of sugar extraction, has made possible one of the great agricultural industries of the temperate zone. The process of improvement has not yet ended.

Sugar-beet environment. While the beet will grow in a very wide range of territory from the tropics nearly to the Arctic, the climatic conditions for beet-sugar production are exacting—a moderate amount of spring and summer rain and a summer of moderate heat, but not too hot, and a cool, dry autumn. The crop should have a growing period of about 5 months in a warm atmosphere, since long hours of daylight are necessary to produce a high sugar content. Corn-growing climates are in the main too warm in midsummer. The cool climates of England and Sweden suit sugar beets. Thus corn and sugar beets are seldom competitors for the same field. Irrigation, especially in America, gives the best conditions for beet growing; and this rarely suits corn because of the coolness of the arid night. In Europe the best region for beets is the great, cool, northern plain from Normandy to central Russia (see Fig. 167).

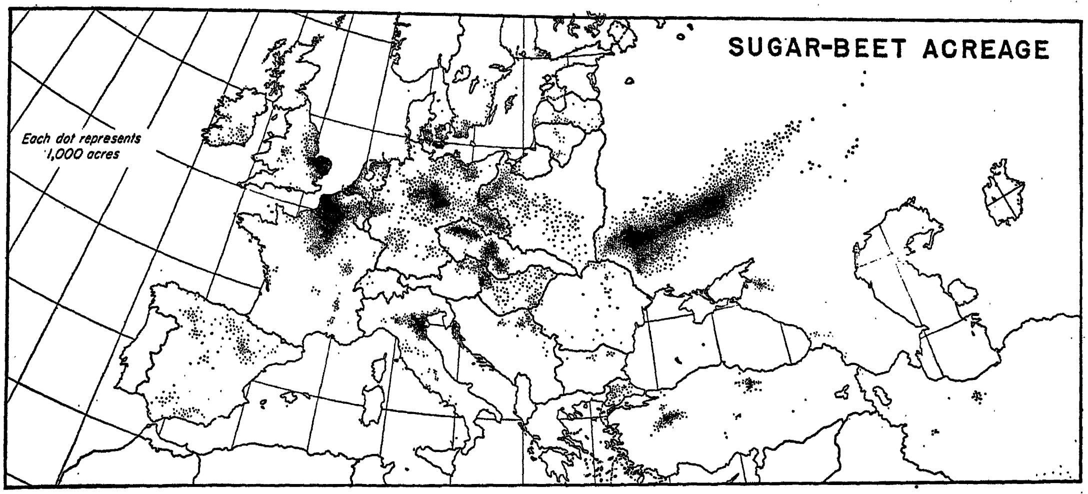
The sugar beet is also quite specific in its soil requirements. The best yields and quality are obtained from fertile, mellow soils rich in lime, and neither too clayey nor too sandy, finely prepared, and plowed so deeply that a subsoil plow must often follow the ordinary plow.

The relation of sugar-beet growing to intensive agriculture. This heavy-yielding, labor-intensive crop fits well into a diversified, intensive-farming system. Caring for the crop has traditionally been most laborious because of the large amount of hand labor required.

The sugar-beet seed sprouts several plants which grow in bunches and have to be thinned. When the plants are small, workers with short-handled hoes remove the beets from segments of the row, leaving "blocks" spaced at the proper interval in the row. Weeds and all beet plants but one are then picked by hand from each block. This blocking and thinning operation is characterized as "stoop" labor—really a euphemism since mostly the laborers, including women and children, work on their hands and knees.

An expert may do half an acre a day. As the season advances the fields are usually hoed twice with long-handled hoes to supplement numerous machine cultivations. Late in the season the beets are loosened in the ground by plows and then pulled and the tops cut off by hand. The topped beets are then sent to the mill. Some mills extract and refine the sugar in a single operation, while others ship raw sugar to refineries.

The by-products of the beet add much value to this crop in the intensive agriculture of a populous country. The tops, when properly cured, contain digestible nutrients equivalent to alfalfa hay, pound for pound. Beet pulp, the fibrous mass that remains after the sugar has been extracted, is also excellent stock feed, either wet or dried. Tops and pulp from an acre of beets equal the stock-feeding value of the entire product from an



Europe also has its beets in spots. *U. S. Department of Agriculture*

average acre of corn.[4] Add from 2 to 2½ tons of sugar, and we see intensive agriculture.

It is, therefore, plain that beet growing plays an important part in cattle-keeping agriculture, especially on the small farms of North Europe. The beet farms are almost universally well cared for, because the beet-manufacturing companies, to assure themselves an abundance of beets, insist in their contracts with the grower that a careful rotation of crops shall be followed. Furthermore, the care and fertilizing required by the beet leaves the field in excellent condition for the production of a fine crop of small grain the succeeding year. This results in such increased yields of grain per acre that it is said that the addition of beets to the crop rotation has not reduced the total grain yield of the beet districts. So neatly does the beet fit into the agricultural economy of Europe, that Europe and the Soviet Union produce over 80% of the world's beet sugar.

European centers of production. While sugar beets are grown in every country of Europe, the major producing areas lie in the great European Plain from northeastern France to the Russian Ukraine. Within this zone are several areas of particularly good soil, favorable climate, and dense agrarian population where sugar-beet culture is especially important. To the west is the fertile lowland of northeastern France, continuing through Belgium into Holland. France usually ranks third in beet-sugar production behind the Soviet Union and Germany, with the Low Countries (Belgium and Holland) producing about half as much (see Fig. 167).

In Germany beet acreage is about equally divided between the eastern and western divisions of that country, but higher yields in West Germany give it a greater production of sugar. In the middle Elbe Valley, near Magdeburg in eastern Germany, sugar beets occupy from one tenth to one seventh of all the cultivated land. Here the beet fields spread in great expanses over the level, perfectly tilled plains, and the landscape is dotted with sugar mills which provide both employment for the laboring populations and feed for the livestock in this intensively used area. Another important district in Silesia has become part of Poland and supplements the substantial prewar producing area of that country.

The easternmost of these major sugar-beet areas is in the northern Ukraine with its flat topography, deep, dark-colored soils, and dense population. The Soviet Union's prewar acreage (3,104,000 in 1934–38) was about two thirds as large as that of all the rest of Europe. Per-acre yields, however, are only one third as high as in the west, owing to less favorable climate (too little rain and

[4] USDA, *Yearbook of Agriculture, 1950–51,* p. 307.

too much heat in the summer), and inferior agricultural methods. Nevertheless, with so large an acreage, the U. S. S. R. is the world's leading beet-sugar producer, with an estimated production of 2.7 million tons in 1954, about equal to the prewar average (see Table 10:1).

Since World War I, Great Britain has actively fostered her sugar-beet industry. Beets occupy over 400,000 acres, mostly in eastern England, and Britain's sugar production about equals that of the Low Countries. Southern Sweden and Denmark are also beet growers, and intensive production is carried on in the upper Elbe Basin of western Czechoslovakia and the Po Valley of northern Italy.

TABLE 10:1. World Production of Centrifugal Sugar for Selected Areas
(thousands of short tons)

	1935–39 average	1945–49 average	1954
Beet sugar			
Western Europe	4,352	3,898	6,770
Eastern Europe	2,925	2,055	3,020
U. S. S. R.	2,761	1,643	2,700
Total	10,038	7,596	12,490
United States	1,517	1,515	2,065
World total[a]	11,772	9,388	15,160
Cane sugar			
Cuba	3,183	5,897	5,000
Other Caribbean areas[b]	2,804	3,492	4,940
Total Caribbean	5,987	9,389	9,940
South America[c]	1,817	2,620	4,060
United States	474	455	552
Hawaii	980	861	1,090
Asia[d]	5,085	2,308	4,655
Australia	894	830	1,425
Africa	1,293	1,449	2,140
World total[a]	16,753	18,038	23,995
World total, beet and cane	28,525	27,426	39,155[e]

a Figures do not add to world total because small producers are not listed.
b Includes Caribbean islands, Mexico, Central America, Colombia, Venezuela, and the Guianas.
c Excludes Colombia, Venezuela, and the Guianas.
d Includes some beet sugar in China-Manchuria.
e In 1953 world production of noncentrifugal sugar amounted to 7 million tons, with India-Pakistan contributing two thirds of this total.
Source: USDA, Foreign Crops and Markets, November 29, 1954, pp. 589–591.

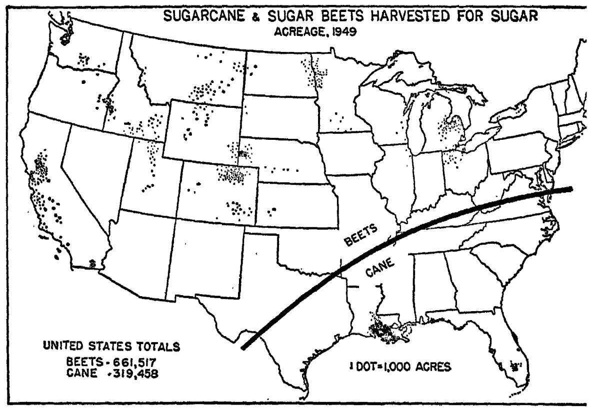
In each of the three periods Caribbean cane and European-U. S. S. R. beets account for about 60% of the world's centrifugal-sugar production. Careful examination of the table, however, reveals important changes between and also within these two major producing zones. What future lies ahead for Cuba as an exporter? What countries have contributed to the steady increase in production in South America and Africa.

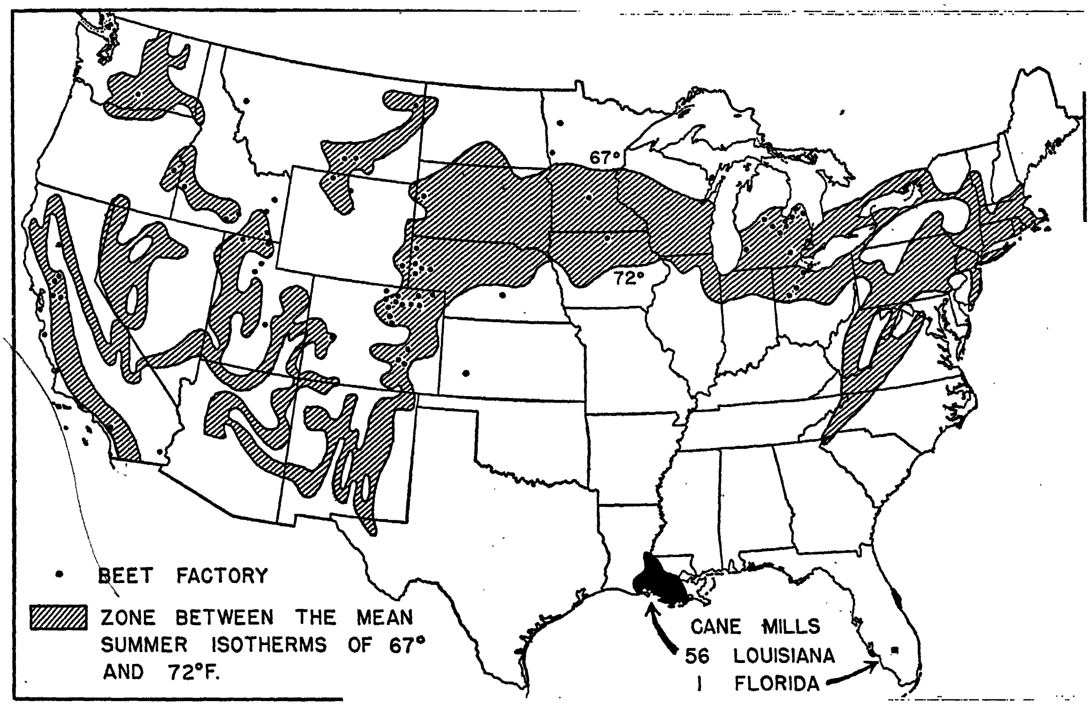
Beet sugar in the United States. As a natural result of the labor and climate required, the sugar-beet industry was late in its development in the United States, although a short-lived beet factory was established at Northampton, Mass., in 1839. The possible beet area of the United States is several times as large as the possible cane area, and seems to follow rather closely the July isotherm of 70°. The sugar beet thus offers a money crop to the American farmer in those regions where the climate is a little too cool for the maximum development of corn. The beet, with its heavy labor requirements, did not interest the American farmer while corn land was still to be had for the taking. The industry had its practical beginnings in the early 1890's, and acreage has grown from 110,000 in 1899 to nearly 900,000 in 1954. The relative importance to some U. S. localities is as great as in any part of Germany.

Its large labor cost, mellow soil requirement, and high yield fit beet growing exceptionally well to the irrigated agriculture of our western Great Plains and Mountain states. Here also the cool, dry weather of September and October produces beets with a high sugar content, and for years Colorado was our leading beet-sugar producer. Beet tops and pulp, usually fed wet, are a major source of winter feed for cattle and sheep in these irrigated districts from western Nebraska to the Pacific mountains (see Fig. 169). So beet growing is virtually a two-crop agriculture, producing sugar and meat.

Similar conditions are found in California, especially the Sacramento valley, which since 1948 has surpassed Colorado in production. In the more humid sections of the country sugar beets are important on the good soil areas around Toledo, Ohio, the Saginaw district of Michigan, and the Red River Valley of North Dakota and Minnesota. In these Midwest areas, as in California, a large

These maps emphasize the importance of temperature conditions for our two domestic sugars—subtropical cane and cool-summer beet. Processing plants are close to the fields. Beet factories generally produce refined sugar. Raw sugar from cane mills moves to 8 refineries (not shown) in Louisiana. Other large, coastal refineries handle imported raw sugar—one each in California and Texas, with 10 more at ports from Baltimore to Boston. *U. S. Bureau of the Census*



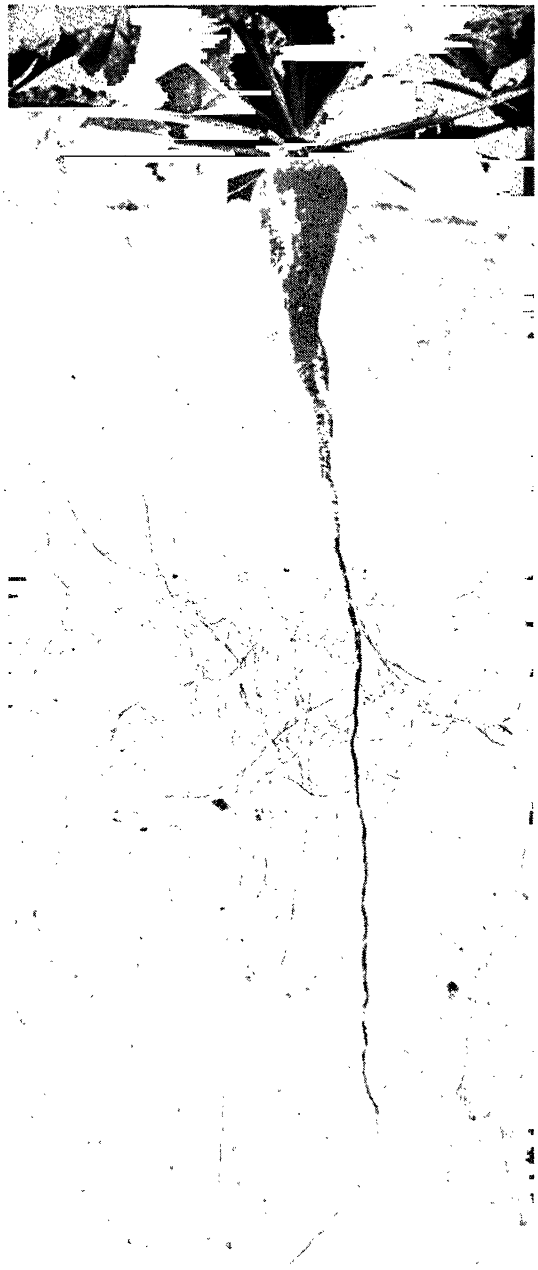


amount of beet pulp is dried for shipment to more distant dairy and stock farmers.

The sugar factories are located close to the beet fields, since beets—the raw material—are a bulky, heavy, low-valued commodity that is limited to a relatively short haul by transportation costs.[5] A mill to process 2800 tons of beets per day costs around $7 million, with $150,000 per year for maintenance. Such a capacity requires production from a large acreage in beets, so the sugar companies enter into long-term contracts with the farmers and assist them in many ways to get the best yields.

Such a large investment also requires the longest possible season for the sake of economy. But the beet grower desires to concentrate his harvest in the short period at the end of the growing season when the sugar content is highest. So beets are stored at the factory to await processing—with the danger of losses due to spoilage and decreasing sugar content. Cost of crop production, factory capacity, and storage losses are thus closely related problems to which scientists, agricultur-

[5] Sugar accounts for about 15% of the weight of the beet, with dried pulp adding another 5%. This 80% reduction in bulk means that the location of the manufacturing plant is largely determined by the location of the raw material (see Chapter 16).



The typical beet shows how it uses deep, mellow soil. It is no rocky-hillside crop. Note substantial amount of top. The beet is nearly a foot long. *U. S. Department of Agriculture*

al experts, and economists give constant attention.

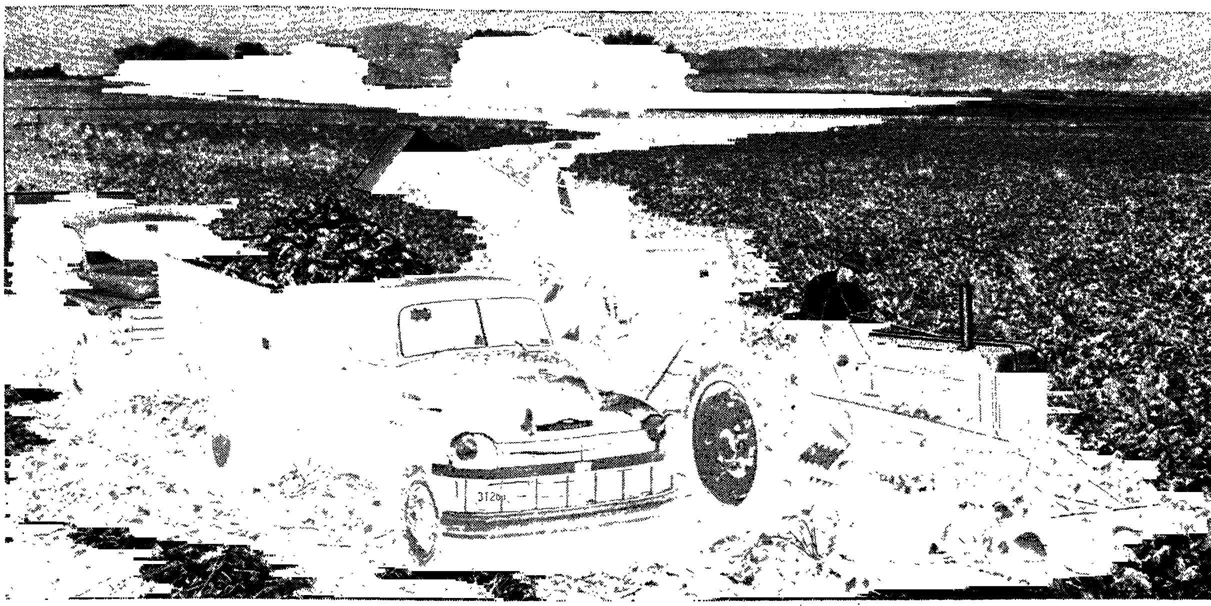
Beets by machinery. Much progress toward mechanization of sugar-beet production has been made in the United States. The use of the tractor and its equipment lowered the labor required to produce and harvest an acre of beets from 120 man-hours in 1915 to 93 in 1936.[6] But blocking, thinning, and harvesting were still largely hand operations, done by contract labor (mostly Mexican in the western areas) with heavy use of child labor for lighter tasks. Recently major progress has been made in the mechanization of these operations, stimulated by wartime shortages and subsequent high costs of labor. In 1946 only 6% of Colorado's beet acreage was harvested mechanically, while in 1952 the percentage was 77.

Complete mechanization of harvest is now common practice, sometimes with a single machine lifting and pulling the beet from the ground, cutting off the top, and elevating it to a truck for the trip to the mill. Mechanization of thinning and weeding operations has been slower, but equipment developed in recent years makes possible at least a 50% reduction in the 20 man-hours of "stoop" labor required to block and thin an acre of beets.[7] As is the case with cotton, the complete mechanization of sugar-beet production poses many technical and economic problems, but the goal may be reached in the not distant future. Even in some European areas considerable strides toward mechanization have already been made.

Governments and beet sugar. The beet-sugar industry in Europe got its start under government initiative and subsidy and has continued to receive deferential treatment from the politicians. Various reasons contribute to this solicitude. It was naturally a part of the desire for national self-sufficiency, which became more intense with the growth of nationalism during the nineteenth century. As we have seen, the sugar beet is a soil-

[6] Figures refer to Colorado. Data on mechanization in this section from Colorado Agricultural and Mechanical College, Experiment Station, *Bulletin 411-A*, "The Economics of Sugar Beet Mechanization," July 1953.

[7] The successful breeding of a one-germ hybrid sugar-beet seed, which sprouts only one plant instead of several, may remove the last bottleneck to complete mechanization. *The New York Times*, August 22, 1953.



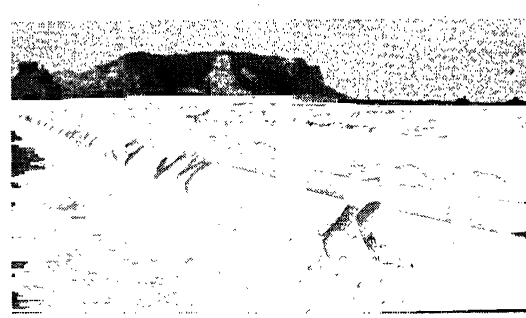
The Machine Age goes beeting in fabulous style. It digs, cuts off the tops, and puts the beets in truck. A second truck follows to take over. A different machine picks up the tops. *John Deere*

conserving and soil-enriching crop whose by-products help to support a dense animal population. It was a crop to which the farmers of Europe, faced with the mounting competition of grain and meat from overseas exporters, could turn.

Powerful agrarian interests, especially in France and Germany, therefore had numerous arguments to use in their successful effort to obtain preferential treatment from their governments. The politicians look with added favor, since the sugar mills provided industrial employment, and taxes on sugar beets were easy to collect and yielded substantial revenue. Since these taxes were levied on beet tonnage rather than sugar content, the beet producers had an added incentive to increase the sugar content of their beets.

The result of these complex geographic-economic-political relationships was a mounting production of beet sugar in Europe, so that by 1900 the beet supplied nearly two thirds and cane only one third of the world's commercial sugar. Several European countries had become major exporters, with their governments paying a bounty on sugar exports. England, the major importer, found that her colonial sugar producers could not meet the competition of these bounty-supported exports and therefore threatened to levy a compensating import duty on all such sugar shipped to England. This led to the Brussels Sugar Convention of 1902 by which the major beet- and cane-producing countries agreed, among other things, to abandon open or hidden bounties on sugar exports. As a result European beet producers ceased to be major exporters, prices declined, consumption increased, and the way was paved for the twentieth-century revival of cane-sugar production (see Fig. 165).

In the United States pressure for the support of the sugar-beet industry resulted from the effort to develop a crop suitable for certain areas north of the Corn Belt and espe-



A sugar-valley feed lot helps to winter feed the animals from open range and mountain pasture. *U. S. Department of Agriculture*

Kukuyu woman carrying home from African tropic garden her family supply of sugar in the cane. The old—very old—industry, widely scattered. ***H. L. Shantz***

cially for the irrigable districts of the West. Sugar-beet production is important in 14 states, with two others producing sugar cane. Thirty-two senators, whose constituents have an interest in sugar, make up a potent force for tariffs and other supports for domestic sugar.

2. THE CANE-SUGAR INDUSTRY

An ancient crop and its development. In contrast to the youthful beet, sugar cane is mentioned in Indian scripts of 5000 B.C. From its homeland in tropical Asia, sugar cane was brought to the Mediterranean by Moors in the eighth century A.D. From here it followed Columbus to the New World, took firm root in the Caribbean islands and Brazil, and moved on to Florida and Louisiana.[8]

From the sixteenth through the eighteenth centuries the industry grew in importance with the expanding colonialism of the European powers. Caribbean islands and Brazil were the important centers. African slaves provided the labor force for the sugar plantations, where the cane was ground in numerous, small, primitive mills to produce a low-grade brown sugar for export. The by-product molasses was the basis for a flourishing rum industry. So slaves, sugar, and rum formed the profitable (to the owners) basis for many a tropic-colonial economy and European colonial policy.[9]

After 1760 this unhappy combination suffered—first, from the military struggles between England and France; then from the emancipation of the slaves, started by the British in 1834; and, finally, from the rise of subsidized beet-sugar production in Europe. The sugar industry in Latin America languished, while the jungle crowded more and more into the abandoned cane fields.

These circumstances did not favor the scientific research and improvements in production which had characterized the beet-sugar industry. But toward the end of the nineteenth century, improved methods of sugar extraction and improved varieties of cane began to revolutionize the industry. This revitalization was stimulated by the increased interest of the United States and Japan in their newly acquired tropical territories, as well as by the decline in beet-sugar exports resulting from the Brussels Agreement in 1902. Cane re-established itself as the cheapest source of sugar; production mounted and now accounts for about 60% of the world supply (see Fig. 165).

The sugar-cane environment. The battle between cane and beet is carried on at long

[8] W. S. Woytinsky and E. S. Woytinsky, *World Population and Production, Trends and Outlook,* The Twentieth Century Fund, New York, 1953, p. 566.

[9] For graphic evidence of the high esteem in which a sugar colony was held, see Vilhjalmur Stefansson, *Northward Course of Empire,* 1922. Benjamin Franklin reported that he had a tough job in persuading the British in 1763 not to give all Canada to France in exchange for Guadeloupe, 687 square miles (sugar and rum).

range, as the plants themselves never meet but their identical sugars most assuredly do. The sugar cane is as distinctly limited to warm climates as the beet is to cool ones. It will grow on the edges of the temperate zones in such districts as Louisiana, Natal, New Zealand, and Argentina, and has been grown at 37°N. Lat. in Spain and 36°S. Lat. in New Zealand, but it is at home and does its best only where free from frost. Since cane usually requires 12 to 24 months to mature, it invades the frost zone only where there is a long growing season and when freedom from competition is provided by means of tariffs and bounties.

The best cane-sugar crops require such conditions as exist in Cuba, Java, Brazil, and India, where there is a temperature of 75° or 80°F. the year round and a rainfall of 60 inches or more. Much sunshine is required, particularly at the end of the growing season, to produce cane with a high sugar content. This makes the Tropical Savanna climate, with its heavy rainfall but also with a distinct dry or less-rainy season, very advantageous for sugar cane. In a similar fashion regions with warm, dry climate in which irrigation can meet the heavy water requirement are also climatically suitable for cane.

Sugar cane can be grown on a considerable variety of soils, but the best yields are obtained from soils which are naturally fertile, with a high water-holding capacity and yet are well drained. The lava soils of Java, the limestone soils of Cuba, and the alluvial soils of many tropical lowlands are examples.

The distribution of cane growing—subsistence and commercial. The adaptation of the sugar cane to practically all moist lowlands lying between Louisiana and Argentina and between southern Italy and India, Natal, and Queensland gives an easy source of sugar to all tropic peoples. Instead of candy the half-naked child sucks a section of cane in many a tropic village. Living and yielding for years beside the native's thatched hut, the cane patch is a pleasing element in that completeness of support for the simple life which the tropical climate yields to man. Although cane growing is a local industry in practically all damp tropic countries, only a few of them export sugar. A crude ox-driven mill will suffice to crush the cane for local use, and it can be boiled in an open pot, but it cannot compete in the world market with the product of the modern centrifugal sugar mill.

Sugar cane for local use is grown in the lowlands of Mexico and of each of the Central American countries, and also in every South American country except Chile. Huge quantities of nonexport sugar are produced and consumed in India and Southeast Asia, while cane is an important and widely distributed source of food throughout thousands of islands from Australia to Singapore and thence to Hawaii and the isles to the southeast.[10]

Within this broad zone where cane grows, the main export supply of sugar has come from especially rich plains and favored humid-tropical shores, such as Cuba (limestone plains), Java (new volcanic soils), Formosa (alluvial plains), with Hawaii, the Philippines, and Puerto Rico sharing these environmental advantages. At no place is cane grown for export in locations distant from the seashore and ocean transport. There must also be an available labor supply[11] and, if possible, political stability—since capital, labor, and a long period of operation are necessary for the economic success of the modern, large-scale

[10] Published estimates give the 1954 production of this locally used, noncentrifugal sugar as 7 million tons, with centrifugal sugar production (beet and cane) amounting to 39 million tons. Two thirds of the noncentrifugal sugar is produced in India-Pakistan. China, Indonesia, Brazil, and Colombia are other important producers on the list. Production of additional thousands (millions?) of tons are not even subject to estimate. USDA, *Foreign Agricultural Circular*, November 29, 1954.

[11] Densely populated areas, such as Java, Formosa and the islands of the Caribbean, provide a local labor supply. In different situations laborers have been brought to the sugar lands in British Guiana as well as to the two tropic islands of Mauritius (British, 720 square miles) and Reunion (French, 970 square miles) in the Indian Ocean near Madagascar. These three and similar spots continue to produce sugar for export, chiefly to their mother countries.

sugar industry. Finally, in recent decades it has become increasingly necessary for a cane-sugar area to have access to an assured market. As with beet sugar, the geography of cane-sugar production reflects a complex of environmental, demographic, economic, and political factors.

Cane-sugar production. Sugar cane is a herbaceous perennial that will continue to send up new shoots for years. Cane planting consists in putting cuttings in the ground or, as in Louisiana and Cuba, in laying in the bottom of a furrow a row of cane stalks which will sprout from every joint. After the growing season, which may vary in length from 8 to 24 months, depending on the climate and the variety of cane, the cane is cut and transported to the nearby mill for crushing. New shoots sprout from the ground, and several crops (ratoons) are often obtained from a single planting. Since yield, both of cane and sugar content, decreases with successive ratoons, it becomes more economical, after several crops, to replant the field and obtain the higher yields from a fresh planting.

Harvesting and transporting the cane to the mills present major problems, since cane yields range from 15 to 30 tons per acre in most areas and reach 80 tons in Hawaii. Cane fields are usually burned to remove the mass of leaves that has accumulated on the ground during the growing season. Hot, quick fires do not damage the cane, but it must be harvested immediately. The man with the heavy knife, laboriously cutting the long, heavy stalks, is the traditional harvester, and much of the world's cane is still cut in this fashion. Hand-loading onto bullock carts or onto small rail cars, drawn by diminutive locomotives over portable tracks, are still common methods for transport.

The mechanization of cane harvest, however, has made considerable progress, especially in high labor-cost areas, such as Hawaii and Louisiana. One method is to use a bulldozer whose blade cuts the cane off a few inches below the base of the stalk and dumps it into piles. A mobile crane, equipped with a grab, then lifts the piles into trucks or onto "trains" of heavy wagons drawn by powerful tractors. These more flexible methods are replacing the sugar-mill railways as well as the water-filled flumes which floated cane to the mills in Hawaii. In Louisiana about 90% of the cane acreage is harvested mechanically.[12]

The sugar *central*. The modern sugar mill, called a *central*, dates from the 1880's and its development was one of the bases for the revitalization of the cane-sugar industry. The *central* has replaced the primitive grinders as well as the steam-powered plantation mills and has become the center around which production is organized. It represents a large capital investment, requires a huge acreage of cane, and must be operated with great skill. The complicated process, although usually continuous, has several well-defined stages. The cane is first crushed in a series of rollers with the addition of water to dissolve the sugar. An accurately measured quantity of lime is added to the resulting juice to prevent the formation of noncrystalline sugar and to aid in the precipitation of impurities.[13] The limed juice is heated and then impurities are precipitated and drawn from the bottom of large tanks. This "sludge" is usually washed and filtered to recover additional sugar before being returned to the fields as fertilizer. The juice, drawn from the top of the precipitation tanks, is evaporated to syrup and then to crystalline form in vacuum tanks, which have replaced the open kettles of earlier days and also

[12] Most mechanical improvements create further problems. In this instance mechanical harvesting means that more leaves and ground trash are picked up, thus creating problems for the crushing mill. But rapid strides are being made in improving cutting and loading equipment, and in adapting mill operations to these new problems. See USDA, *Yearbook of Agriculture, 1950–51*, pp. 293–299.

[13] This critical process must be adjusted to meet the specific characteristics of the cane being crushed, which often change from hour to hour. In the older *centrales* "liming" was an art requiring great skill on the part of the operator that now has been displaced by devices which quickly analyze the cane in process and automatically add the proper amount of lime. *Ibid.*, pp. 294–295.

made this process one of scientific control instead of "artistic" skill. Finally, molasses is spun from the crystalline mass in centrifugal machines, leaving raw, brown sugar, the final product of the *central.*

Like the beet sugar factory, the *central* must be close to a large cane-producing area, for sugar amounts to only 10% to 15% of the cane by weight. In addition, harvested cane deteriorates more rapidly than do beets and must be crushed within 24 to 48 hours if losses are to be avoided. However, tropical climate, with its continuous growing season, provides a compensating advantage in this regard. A carefully worked-out sequence of planting, perhaps using several varieties of cane, may extend the harvest and the operating period of the mill over many months. Consequently, not only must the cane acreage be large, but its production must be tailored to fit the operating requirements of the *central.*

This causes sugar corporations to own and operate large acreages of cane land, and also, in some areas, to contract with "independent" farmers for delivery of cane. The latter may range from large estate-owners to small farmers in a "sharecropper" status. In contrast to sugar beets, cane is usually produced under a single-crop system and generally is by far the most remunerative crop which can be grown. Consequently, a reasonable contract policy generally assures a dependable supply of cane to the *central*—as long as the land retains its fertility.

The raw sugar produced in the *central* is always shipped to a refinery, a further contrast with beet-sugar production. Most of the refineries are located in the consuming countries, partly as a result of historical developments and partly because a refinery has the capacity to handle the output of a number of *centrales.* However, refineries have been built in such important producing areas as Cuba, so that importing countries find it necessary to protect their refining industry by tariff and other limitations on the import of refined sugar from the tropics.

By-products of cane sugar. By-products have not been so significant in the cane-sugar as in the beet-sugar industry, but their importance is increasing along with the great technical improvements of the past half-century. Bagasse (the fibrous residue from crushed cane) has long served as the chief fuel for the *centrales.* More recently, especially in the United States, it has been used in the manufacture of insulating wall board,[14] and for poultry litter and mulch. It is also a potential source of cellulose for the paper and plastics industries, awaiting the development of a low-cost method of separating the high-quality cellulose from the pith.

A sugar *central* may produce half as much molasses as sugar,[15] some of which is edible. Blackstrap molasses, from which all crystalline sugar has been removed, is inedible but pregnant with chemical possibilities. It contains noncrystalline sugar and is a cheap source of industrial alcohol, much of which was produced during World War II to supply our synthetic rubber industry. It is also a valuable cattle feed, since 10 pounds of molasses, with the addition of 2 pounds of cotton-seed meal, are almost the exact equivalent of 10 pounds of corn as stock feed. Aconitic acid, important to the plastics industry, is one of the many possible derivatives of molasses and has been commercially produced, while an industrial wax is obtained from sugar "sludge."

The chemistry of sugar and its by-products rivals that of coal-tar and petroleum, both in its complexity and in potentialities for a great variety of products which may have an important bearing on the industry.

[14] The interest of the Celotex Company in bagasse as a raw material for its wall board led the company to assist in the revival of Louisiana's sugar industry, devastated by mosaic disease in the mid-1920's. See E. W. Zimmerman, *World Resources and Industries,* rev. ed., Harper & Bros., New York, 1951, p. 241.

[15] Some idea of the quantities involved may be gained from the fact that from a Louisiana cane crop of 5,250,000 tons (1948) came 370,000 tons of sugar and 220,000 tons of molasses, while 1,500,000 tons of bagasse accumulated. Remember, however, that the sugar content is much lower than that of cane from more favored areas.

3. MAJOR CANE-SUGAR PRODUCERS

Politics again. For the last 25 years sugar production and trade has been carried on under a controlled system of international agreements, quota restrictions, and preferential arrangements. Political and economic relationships that assure market outlets are often of equal, and sometimes of greater, importance than favorable environmental conditions to a producing area. The United States is by far the leading import market. Our domestic production of beet and cane sugar amounts to little more than one fourth of our 7.5 to 8 million-ton consumption. Consequently, we receive between 5 and 6 million tons a year, which comes almost entirely from Hawaii, the Philippine Islands, Puerto Rico, and Cuba (see Table 10:2). Access to the United States market, where they have long received preferential treatment, is thus vital to the sugar producers in these four areas.

TABLE 10:2. Sources of Sugar Consumed in the United States
(per cent of total consumption)

	1934–41 average	1942–47 average	1953
United States			
beet	23.2	22.0	23.4
cane	6.3	6.8	6.5
Cuba	28.6	44.6	28.4
Puerto Rico and Virgin Islands	12.1	13.0	14.2
Hawaii	14.0	12.1	13.7
Philippines	15.4	.3	12.6
Other	.4	1.2	1.2
	100.0	100.0	100.0
U. S. consumption, thousands of tons	6885	6346	8000

Source: United States Cuban Sugar Council, *Sugar Facts and Figures*, 1952, pp. 34–35. USDA data for 1953.

Quotas set by the Sugar Acts of 1934 and 1937 governed our sources of supply in the 1934–41 period. Then, during World War II, quotas were suspended, supplies from the Philippines were cut off, and Cuba regained the position she had held prior to 1930. The Sugar Act of 1948 and its amendments re-established the quotas, and our 1953 sources of supply were about as they had been prior to World War II. Note how stable have been the percentages supplied by our two domestic sources.

Hawaii. Large-scale sugar production began in the 1870's in our Hawaiian Territory, making it the oldest of our important sources of overseas supply. The islands have consistently supplied from 10% to 15% of our requirement. The sugar yield per acre is the highest in the world, partly due to the fact that the cane is given from 18 to 24 months to mature but also due to the virgin fertility of the phenomenal soil—decayed lava from the great Hawaiian volcanoes. Fine yields are further guaranteed by commercial fertilizer, skillfully applied, and by irrigation on the leeward side of the islands. In the absence of suitable rivers at the right elevation for stream diversion, tunnels have been dug to carry water from windward to leeward side of several islands. Water is also gathered near sea level from streams and wells, pumped up (sometimes hundreds of feet) through iron pipes, and spread over the fertile lava slopes, making some of the most spectacular plantations in the world. All this effort can be afforded because of free entrance into the American protective tariff market. But the yield! It is 7–8 tons of sugar to the acre, compared to Puerto Rico's 3+, Philippines's 2, Florida's 3+, and Louisiana's 1+.

This special privilege has continued under the quota system that now governs our sugar supply and has led to high profits and the dominance of the sugar industry in the Hawaiian Islands. These profits began when the islands had a few thrifty white people and many easy-going natives, giving an admirable opportunity for the formation of great estates which loudly called for workers. These came from China—until the Chinese exclusion treaty shut them out in 1898. Then came Japanese—until the Japanese government checked emigration to the islands.

Despite efforts to obtain labor from other countries, population has increased more slowly than in most tropical areas. Cane production is highly mechanized and carried on by large corporations who operate their own acreage with little dependence upon the independent cane grower. These corporations control all stages from cultivation to the refining

of sugar in refineries located in Hawaii and the United States. Cane production in Hawaii has about reached its economic limit because most of the suitable land has been planted.

The Philippine Islands. The dominant interest of the United States in our other three "off-shore" sugar suppliers dates from the Spanish-American War, when the Philippines and Puerto Rico became our territories and the Spanish lost control of Cuba. The Philippines, nearly 3 times as large as Cuba and 15 times the size of Hawaii, have admirable soil, temperature, and rainfall for the growth of sugar cane. Production of centrifugal sugar surpassed that of inferior types after World War I. By 1939 the Philippines were producing about 1 million tons a year, most of which went duty-free into the United States. Most of the cane is produced by independent growers and their tenants and ground, on a custom basis, in *centrales*.

Now independent, the Philippine Republic continues to receive a quota allotment from the United States and also has a preferential tariff arrangement which will gradually disappear in years to come. In 1954 the crop reached 1.4 million tons—a third above the 1935–39 average. The United States quota is 1.2 million tons for Philippine sugar, while the Philippines receive a quota of only 24,570 tons (1953) on the world "free" market, a striking indication of the importance of the United States to the new republic.

Puerto Rico. With a population of 2 million, 5 times that of Hawaii on but half the area, Puerto Rico clearly shows the advantage of free admission of sugar into the United States. After annexation, production increased rapidly and for the last 20 years has been about 1 million tons a year—roughly the same as Hawaii and the Philippines.

The sugar is grown on the coast lowlands, the windward northeastern side having sufficient rainfall for the crop in most places, but on the drier southwestern side irrigation is necessary. Practically all the suitable cane-growing land has been planted for 20 years. Production costs for sugar are considerably higher in Puerto Rico than in Cuba, because of the necessity for using fertilizer and the greater expense of cultivation. The success of cane planting in Puerto Rico has come about largely through the consolidation of many small plantations and the modernizing of factories by U. S. capital and management. Owing to population pressure and scarcity of available land, sugar acreage has been relatively stable since 1920. Yields per acre have increased, and Puerto Rico's 30 tons of cane per acre (1948–52 average) is much above Cuba's (17 tons) or the United State's and the Philippines's (20 tons).

Cuba. Cuba has doubled its prewar production to become the world's leading producer of centrifugal sugar.[16] In the years 1949–53 Cuba's average annual production of 6.3 million tons, despite restrictions during the last two years, amounted to over one third of the world's cane and nearly one sixth of the total beet- and cane-sugar production. Cuba is clearly the major source for the United States, the one with the greatest potential, and the only one with a major surplus for export to other areas. Although not a territory, Cuba has had close economic and political ties to the United States as well as tariff preferences on sugar beginning in 1901 and quota allocations since the mid 1930's.

These arrangements, however, have not prevented great fluctuations in the Cuban sugar economy, due to changes in world price as well as the U. S. tariff (see Fig. 179). Nevertheless, conditions have been favorable for the investment of foreign capital, chiefly American, which dominates the industry. Large corporations are the rule, especially in the newer areas of eastern Cuba. They own and operate the *centrales* together with large acreages of cane land. Supplementary contracts with independent cane growers have

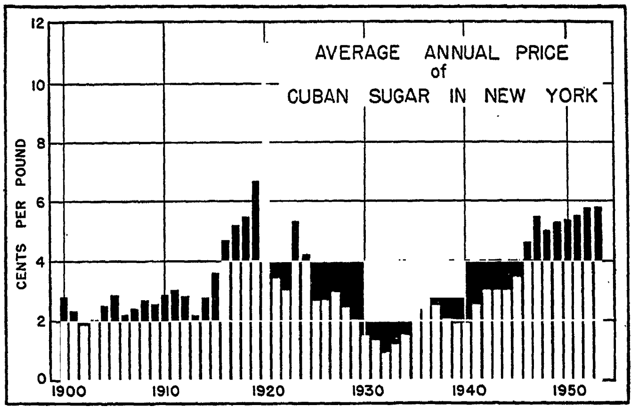
[16] Counting their huge tonnage of noncentrifugal sugar, the combined production of India-Pakistan is somewhat ahead of Cuba's. But this noncentrifugal sugar does not enter into international trade, and India and Pakistan have been importers in recent years.

brought the latter increasingly under the control of the corporations, because their operations are determined by the production requirements and schedules of the *centrales*.

Cuba has been able to produce such great quantities of sugar because she has had a fairly stable government, a population superior to that of most tropic countries, and an abundance of good, smooth, rich, well-drained limestone land. Only one twelfth of the island is in cane fields, so the planters exploit land as we do in the United States. When land became exhausted, the industry has been able to move, generally to the eastward from Havana where the industry had its first center. The increasing labor scarcity was a limiting factor before the overproduction of sugar of the 1930's.

Although the United States takes over half of Cuba's exports, a substantial amount goes to Great Britain and other importers.[17] The failure of Indonesia to re-establish Java's earlier importance in sugar export leaves Cuba by far the most important supplier of sugar to the free world market.

Cane-sugar production in the United States. Our own small cane-sugar industry is an example of production in a subtropical area, where conditions are distinctly marginal for cane and where the industry could not survive without the protection of tariff and quota allotments. The most important area is in southern Louisiana,[18] where the sugar territory is part of the swampy flood plain of the lower Mississippi Valley. The only tillable land is within a mile or two of the Mississippi or other streams, where deposits from past floods have built up the land a few feet above the general swamp level. This is fertile soil, and it is estimated that there are 10 million



The Spaniard is not so thrifty as the Scot or the Yankee. The shower of gold that fell on Havana in 1919 and 1920 started the construction of a row of palaces along the shore near Havana. Ten years later the trade wind murmured softly through unglazed windows of many still-unfinished structures. The reason for attempts at control of international sugar are manifest. ***United States Cuban Sugar Council data***

acres of good cane land but that we plant only one thirtieth of it.

Climate is the chief limiting factor that makes this area inferior to the tropics. Cane cannot survive even the mild winter of southern Louisiana, and so must be planted each year in contrast to the several ratoon crops generally obtained from a single planting in Cuba and most other tropical areas. This increases the costs, since preparation of the land is the most expensive part of cane production and also since about 20,000 acres are needed to supply seed cane for the annual plantings. The 8-month growing season (short for cane) and frost damage result in lower sugar content—an average of 160 pounds of sugar per ton of cane in the United States as against tropical yields from around 233 pounds (Hawaii, Philippines, and Puerto Rico) to 254 pounds per ton in Cuba.

Higher labor costs are a further competitive disadvantage, only partially compensated by

[17] 1952 Sugar Exports from Cuba (thousands of tons)

United States	2889
Great Britain	597
Other Europe	887
All other	1141
Total	5514

Source: USDA, *Foreign Agriculture Circular* (FS 2–53), May 20, 1953, p. 4.

[18] Of the 343,000 acres harvested in 1952, 299,000 were in Louisiana and 44,000 in the Everglades district of Florida. An additional 30,000 acres of cane harvested for syrup were scattered from Louisiana to Georgia.

mechanization. Despite its location close to the market for sugar and the by-products of the cane mill, our domestic cane industry has expanded little in recent years and now produces about 500,000 tons of sugar—much less than our production of beet sugar and only 6% to 7% of our total sugar requirements (Tables 10:1, 10:2). Without protection from the competition of tropical sugar, this long-established industry would quickly disappear.

Sugar for the British Commonwealth. Great Britain is second only to the United States as a market for imported sugar, and, like ourselves, the English have developed a variety of sources to meet their requirements. They have fostered their domestic beet-sugar industry and now produce about half as much as we do. Tropical possessions, particularly in the Caribbean area, have supplied some sugar to Great Britain since the sixteenth century. British West Indian islands, such as Jamaica, Barbados, and Trinidad, where conditions for sugar production are comparable to those in Puerto Rico, now supply about 300,000 tons per year.

British Guiana, on the northeast coast of South America, has a sugar industry of a different type. Here laborers have been imported from India to clear, drain, and dike the coastal swamplands. Once reclaimed, this land is easily irrigated and produces high yields of sugar and rice, both of which are largely exported. The result is intensive, commercial agriculture side by side with untouched wilderness.

Non-British exporters in the Caribbean are actually more important sources of England's supply than the colonies, which are small and have limited possibilities for expansion. Cuba is the most important source for Great Britain, she also takes nearly the entire export crop from the independent Dominican Republic and a substantial tonnage from Puerto Rico. These various exporters make the Caribbean area the major source of British supply (see Table 10:3) just as it is for the United States.

This parallel can be pursued even further. Great Britain has a small-scale Hawaii in the Fiji Islands in the South Pacific, with Mauritius constituting a large-scale version in the Indian Ocean. Commonwealth policy pushes sugar production to and beyond the tropic margins in Africa and northeast Australia—developments somewhat similar to our own in Louisiana. Australia is the most important producer despite the exclusion of nonwhite laborers, who had been the planters' chief dependence, in the interest of the "white Australia" policy. By 1954 production had increased to 1,425,000 tons in Australia, 812,000 in the Union of South Africa, and 275,000 in British East Africa.

TABLE 10:3. Sugar Imports of the United Kingdom, 1952

(thousands of short tons—raw value)

Caribbean area	
Cuba	621
British possessions	563
Dominican Republic	485
Puerto Rico	90
Total	1,759
Mauritius	285
Australia	134
Fiji	10
Other	125
Total imports[a]	2,313

[a] A million tons of these total imports were from British Commonwealth countries. The United Kingdom exported 811,000 tons (raw value), mostly of refined sugar, making a net import of 1.5 million tons.

Source: USDA, *Foreign Agriculture Circular,* October 14, 1953.

The unique case of Java. A quarter of a century ago, Java was second only to Cuba in sugar production for export. At present, Indonesia's production of 660,000 tons (1953) is less than one fourth of the peak in the late 1920's, while exports, which had averaged 1 million tons per annum as late as 1935–39, have virtually disappeared. This collapse has come about despite the fact that, under the Dutch, Java had developed what was probably the world's lowest-cost sugar production. Environmental conditions were especially favorable. Java's volcanic and alluvial soils were exceptionally deep and fertile, especially for an area in the humid tropics where leached, infertile soils are the rule. Lying close to the equator, Java is humid and constantly warm.

Moreover, in eastern Java, the main sugar area, a less-rainy season provides a ripening period during which cane can develop a high sugar content.

The large population (about 50 million in 1950) provided a cheap labor supply, while the population density of over 800 per square mile required intensive production methods. Even in 1930 about 40% of the total area was under cultivation, which meant that sugar companies could not find new lands to bring under cultivation as was the case in Cuba. Under government regulations the sugar mills could not own the cane land but could only rent it from the natives, with the further restriction that a given piece of land could remain in cane for only one season.[19] This made ratoon crops impossible and stimulated the production of single-season cane with heavy yield and high sugar content. Much research was devoted to irrigation methods, production techniques, and, especially, to cane breeding. One new variety, the famous P.O.J. 2878, is said to have increased the per-acre yield of Javanese sugar by nearly 25%. This variety was widely planted in cane areas throughout the world, crossed with local varieties, and thus contributed substantially to the increase in sugar yield during the interwar period.

A favorable environment, cheap labor, and intensive scientific research thus combined to make Java a low-cost producer of export sugar, which moved to Europe but in larger amounts to India and other Asiatic areas. However, India was successful in her efforts to achieve self-sufficiency, while Japan developed her own sources of supply in Formosa, where conditions were comparable to Java in many respects. During the period of low prices of the 1930's Java's mills were abandoned; production and export declined. Recovery has been forestalled by the disorganization of World War II and the political and economic problems of the newly independent state of Indonesia. Here is a case in which close economic and political ties to a major consuming country seem to have been more important than favorable environment and low costs of production in securing the continuance of an important export industry. Indonesia increased its population about tenfold in a century under the scientific paternalism of the Dutch; it was conquered by the Japanese, injured by war, and became independent—with plenty of problems. It will be an interesting country to watch.

International trade and international agreements. From what has been said it is clear that the production of the great proportion of the world's commercial centrifugal sugar takes place in two broadly different situations, represented by beet sugar in Europe and the Soviet Union and cane sugar, for which the Caribbean area is the most important source of supply (Tables 10:1, 10:4). Further, it has been brought out that the distribution of producing areas and of world trade in sugar has been strongly influenced by the policy of beet-sugar countries to protect their industry from the competition of cane sugar—the production of which has itself been "protected" in many areas.

The effort to deal with the instability of the sugar market, which is inherent in the above conditions, has resulted in an increasing channelization of trade and restriction of the "free" market for sugar. Thus the United States imports almost exclusively from the four overseas areas with which it has strong political and economic ties. Prior to World War I, Great Britain imported relatively little from its colonial territories. But since World War II, upwards of 40% of Britain's net import of around 1.5 million tons per year comes from such areas. Sugar production in the British Commonwealth has expanded, and most of it moves within a complicated system of quotas,

[19] These regulations, designed to protect the local food supply for the population from complete domination by sugar interests, have made adjustment following the decline of the sugar industry somewhat easier.

TABLE 10:4. International Trade in Centrifugal Sugar
(thousands of short tons)

Leading exporters	1935–39 average	1945–49 average	1953
Cuba	2,871	5,245	6,081
Other Caribbean[a]	2,133	2,085	2,909
Total Caribbean	5,004	7,330	8,990
Hawaii[b]	963	739	1,086
Formosa	1,024	161	1,020
Philippines	892	137	866
Australia	471	273	816
Mauritius and Reunion	394	421	696
Peru	327	333	454
East Europe and U. S. S. R. (beet)	1,076	153	265
Total, listed countries	11,182	9,576	14,294

Leading importers	1935–39 average	1945–49 average	1953
United Kingdom	2,058	1,493	2,621
Other West Europe[c]	1,485	1,120	1,335
Total West Europe	3,543	2,613	3,956
U. S., imports	2,907	3,246	3,754
U. S., from territories	1,872	1,707	2,208
Total U. S.	4,779	4,953	5,962
Canada	483	510	579
Japan	872	233	1,168
China	334	21	d
Chile	141	169	247
Total, listed countries	10,152	8,499	11,912

a Includes Caribbean islands, Mexico, Central America, Colombia, Venezuela, and the Guianas.
b Shipments to the United States.
c Excludes Soviet satellites. France, the Low Countries, and Spain are important exporters.
d Not available.
Source: USDA, *Foreign Crops and Markets,* August 16, 1954, pp. 166–169.

Explanation of the figures in this table provides another opportunity to test your knowledge of the complex world trade in this important commodity. The dominance of the Caribbean area in sugar export and the importance of western Europe and the United States as import markets are clearly revealed. Not shown, however, is the complex trade *among* western European countries, some of which (such as France, the Low Countries, and Spain) are important exporters of beet sugar, with the United Kingdom also re-exporting imported cane sugar.

preferences, etc., which make up the Commonwealth Sugar Agreement.[20]

Japan followed a similar policy in the inter war years, with Formosa, at that time her colony, sending virtually all her exports to Japan.[21] Western European countries other than Great Britain also have a net import requirement of about 1.5 million tons despite their substantial production of beet sugar. This comes from a variety of sources: beet sugar from exporters on both sides of the Iron Curtain as well as cane sugar from colonial and other areas in the tropics.

This control of production and channelization of trade has been increasingly regulated by international agreement. The collapse of sugar prices in the mid-1920's caused producers in Cuba to restrict production in an unsuccessful effort to improve prices. In 1930 producers in several countries signed the Chadbourne Agreement, aiming at a similar purpose. But the continuing depression, together with the increase in sugar production in countries not in the agreement, doomed it to failure.

In 1937 the International Sugar Agreement was negotiated among 22 nations which included the important producing and consuming countries. By a complicated series of arrangements, export quotas were set and the exporting countries agreed to limit their production in line with the quotas. Similarly, the importing nations, most of whom were also sugar producers, agreed to control their domestic production and obtain part of their import requirements from other nations signing the agreement.

Operation of this arrangement was cut short by World War II, but it remained in existence and was the basis for a new agreement, signed in 1953, which included somewhat more flexible provisions for adjusting quotas (and production) with the fluctuations of sugar prices. The provisions of these agreements are implemented by legislation of the various

[20] In 1952 countries of the British Commonwealth exported 2,743,000 tons of sugar (including re-exports), but only 482,000 tons of this total went to *non*-Commonwealth countries.

[21] In the years 1935–39 Formosa and Java each exported 1 million tons. But Japan remains an important market for Formosan exports which had recovered to 518,000 tons in 1952. Note the striking contrast.

countries as, for example, the Sugar Acts of the United States and the British Commonwealth Agreement, which set quotas for the various areas supplying these important consumers.

Production outside the agreements. Several important producing areas are relatively little affected by the international trade and agreements discussed above. Brazil, an important exporter prior to the nineteenth century, has modernized much of its sugar industry. Production has increased but is mostly absorbed by the internal market with little for export. The Soviet Union and her satellites in eastern Europe (especially Poland, Czechoslovakia, and East Germany) are major producers of beet sugar with some exports and a greater export potential. China produces both beet and cane sugar. Prewar imports have disappeared and, as in so many things, China's potential for sugar production remains a question. India, included in the Commonwealth Agreement, produces and consumes a huge amount and imports a small amount by comparison. Whether it can change this near-self-sufficiency into an export potential is also a question for the future. Will present population increase continue without famine check?

4. OTHER SOURCES OF SUGAR

Sugar from sorghum. The significant sugar-containing plants aside from cane are not limited to the tropics.[22] Sweet sorghum, or sorgo, is an annual resembling both kafir corn and broom corn and has long been grown in southeastern United States for the manufacture of sugar for local use. The juice may be extracted and treated the same way as the juice from sugar cane, although in the United States it is generally used for syrup. Since, as we have seen, sorghum is widely grown in Asia and Africa, it forms an important source for locally consumed sweetening in areas where sugar cane cannot be grown. In the United States, corn itself is more used for the production of sweet syrup than is sorghum and even the busy bee is more productive.[23]

Maple sugar. Maple sugar is produced by the evaporation of the sweet sap of several varieties of maple which will grow over large areas of eastern and northern United States, where it was a very important factor in the days before world commerce in sugar. The sap flows only for a few days in quantities sufficient for satisfactory sugar making where the days are bright and sunny and the nights are cold. This climatic factor limits sugar orchards to the region from Indiana east and north. It is particularly important in New York, the mountain region of Vermont and New Hampshire, and the adjacent parts of Canada, from which we import nearly as much as we produce.

The sugar maple tree that yields from the time it is 20 or 25 years old until it is 75 or 100 certainly has all other sugar producers distanced for permanence, but at present the yield is low—its sap .05% to (rarely) 7% sugar—makes 1 to 7 pounds of sugar per tree.

We got the industry from the Indian, and have done nothing to improve the tree.[24] It is anybody's guess as to what would happen if it should receive the genetic attention that has been bestowed on the sugar beet.

[22] It should be remembered that noncentrifugal sugar is the most important "other" type of sugar (see page 173 above). Its widespread production and use remains an ever-present reminder of the potential of the tropics for the production of commercial grades of sugar.

[23] U. S. Production of Selected Edible Syrups and Honey, 1952 (thousands of gallons)

Corn	127,405
Cane	6,040
Sorgo	2,831
Maple	1,631
Honey	23,155

Source: USDA, *Agricultural Statistics, 1953,* p. 100.

[24] See J. Russell Smith, *Tree Crops,* Devin-Adair Co., New York, 1953.

11· Condiments and Tobacco

1. COFFEE

Enjoyment goods. Coffee, tea, cocoa or chocolate, the cola drinks, and tobacco are enjoyment goods that are prized for their flavor, aroma, or stimulating qualities. Cocoa alone has food value. All except cocoa tend to become firmly established in the daily life of the users. Coffee, tea, and the cola drinks derive their stimulating and habit-forming qualities from caffeine; cocoa, from theobromine; and tobacco, from nicotine. Unlike whisky, wine, and beer, they result in temporary stimulation with no secondary stage of depression—that is to say, no hangover.

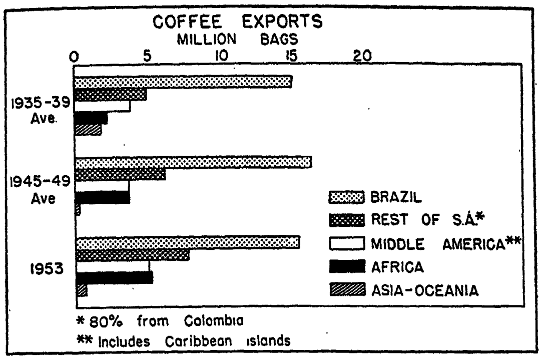
The Englishman loves his tea as the American loves his coffee. It is hard to realize that coffee was the preferred beverage in Great Britain until about the middle of the eighteenth century. At that time London alone had several thousand coffeehouses, where men met to drink coffee and to discuss business and political affairs. The East India Company held a monopoly on the trade in tea and was pushing the sale of its product. So successful was the company's propaganda that the British people were converted from coffee to tea drinkers within the space of a few years.[1]

Man is a creature of habit. Dietary revolutions are exceptional. The consumption of enjoyment goods usually increases with the growth of population and purchasing power, although significant changes may occur. Thus, the per-capita consumption of coffee in the United States increased from 3 pounds in 1830 to 9 pounds in 1913 and to 14 pounds in 1935–39. World War II greatly stimulated the demand for coffee outside the home. Men in the service acquired the coffee-drinking habit or drank more coffee than ever before. Workers in many defense plants were served coffee on the job. Today many a factory and office worker takes time off from work to relax over a cup of coffee. In 1953 the average American drank about 17 pounds of coffee in spite of high prices, as compared with a peak consumption of 19 pounds per capita in 1949.

World trade in coffee. Unlike wheat, rice, and corn, coffee is not a staple handed down from distant ages. The coffee tree is probably a native of Ethiopia, whence it was taken to Arabia. Coffee drinking was common in Arabia in 1500 A.D., and the habit soon spread to Egypt, Turkey, and other Mediterranean lands. Western Europeans acquired it in the seventeenth century about the same time that tea and tobacco were introduced. As a major staple of commerce, however, coffee belongs to the nineteenth and twentieth centuries.

The chief source of commercial supply has shifted much. At first, it was Arabia, then the West Indies, then Java, and lastly Brazil. Most recently, tropic Africa has risen in importance, exports more than doubling since 1939 (see p. 185 top). In 1953 Latin America

[1] William H. Ukers, *All About Tea*, 2 vols., The Tea and Coffee Trade Journal Co., New York, 1935, Vol. 1, p. 67.



Increase in Africa largely colonial influence despite coffee forests in Ethiopia. ***USDA data***

provided 83% of the world's coffee exports; Africa, 15%; and Asia and Oceania, only 2%. Brazil accounted for 49% of all coffee exports, as compared with 62% in prewar years.

Latin American coffee exports are worth more than $2 billion annually and account for one fourth of the region's export trade. Coffee comprises nine tenths of all Salvadorean exports, three fourths of those of Colombia and Guatemala, three fifths of Brazilian exports, and more than one half of the exports of Nicaragua and Haiti. In three countries—Costa Rica, Ecuador, and the Dominican Republic—coffee makes up 25% to 50% of the export trade. The United States buys 95% of its coffee from Latin America.[2]

The United States and Europe are by far the largest markets for coffee. New York, New Orleans, and San Francisco receive most of the coffee shipped to this country, while Le Havre, Antwerp, and Hamburg are the chief ports of entry in Europe. Coffee shipments to Europe were cut to one fourth of their prewar volume during World War II, and they have recovered slowly in the postwar era. In 1952 European coffee imports were 14% below 1935–39 (see Fig. 185 bottom and Table 11:1). In contrast, the American demand never slackened. In 1953 about 21 million bags of coffee, or 62% of the

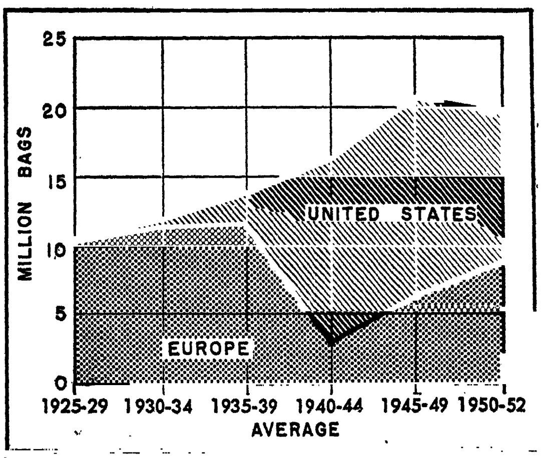
TABLE 11:1. Per-capita Consumption of Coffee in Selected Countries
(pounds)

Country	1935–39 average	1953
United States	14.0	16.7
Sweden	17.6	15.8
Brazil	15.6	13.2
Finland	13.7	12.3
Denmark	18.0	11.9
Belgium-Luxembourg	12.9	11.3
Switzerland	9.1	8.8
Canada	3.6	7.1
France	9.7	6.6
Netherlands	9.5	5.6
Germany	4.9	3.8[a]
United Kingdom	.8	1.3

[a] Data for West Germany.
Source: 1935–39 data, Vernon D. Wickizer, *Coffee, Tea, and Cocoa,* Stanford University Press, Stanford, Calif., 1951, p. 76. 1953 data, The Tea and Coffee Trade Journal Co., New York.

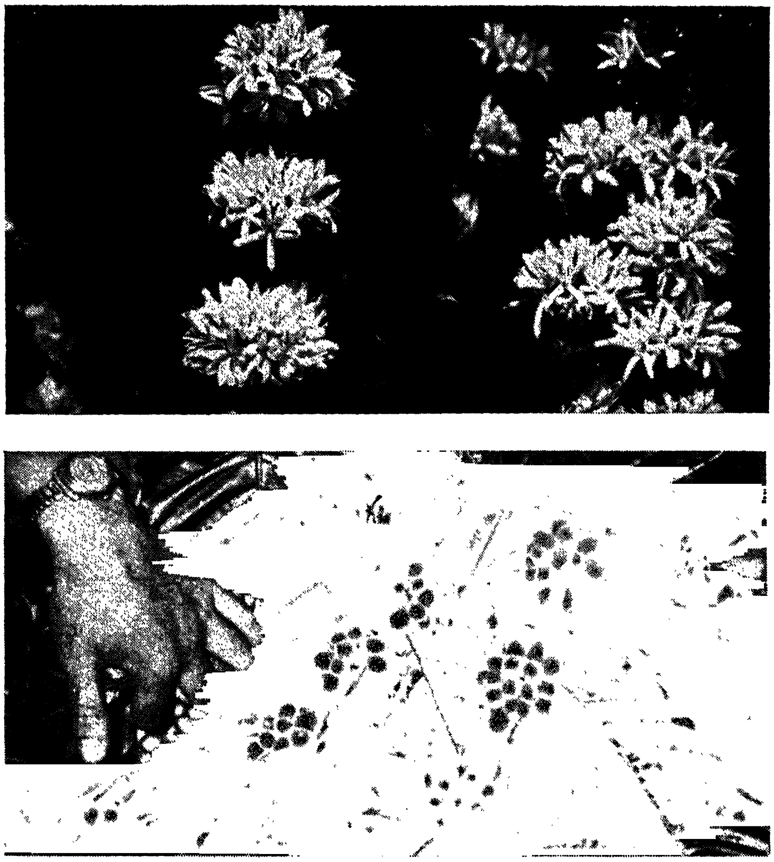
world's exports, were destined for the United States.

The coffee environment. The coffee tree requires heat, humidity, abundant rainfall, and a rich, well-drained soil. Most of the world's 6 billion coffee trees are found in highland areas within 24° to 25° of the Equator. Nearly all the major coffee-producing regions lie near the sea, a distinct advantage for export. Most coffee is grown where the average



Coffee imports. Both lines read from zero. ***Chase National Bank***

[2] See "Coffee and Latin America," *Latin-American Business Highlights,* The Chase National Bank, New York, June 1953, pp. 1–6.



Coffee blossoms, coffee berries. The watch? One of the industrial photographer's troubles—the subject will overdress. A Japanese cotton mill photo showed supervisor with full dress and white tie. *Federation of Colombian Coffee Growers* (top), *Ecuadorean Embassy, Washington, D. C.* (bottom)

annual temperature is between 63°F. and 77°F. Although coffee requires a hot climate, in many regions the full blast of the sun is too hot for it, and high trees are scattered over many plantations to cast some shade. Young coffee trees are grown with bananas, corn, or other crops to protect them from the full rays of the sun and also to reap the profit of a side crop.

The principal coffee-growing regions have an average annual rainfall of about 60 to 70 inches. In a few areas coffee is grown with as little as 40 inches of rain; in others, with as much as 120 inches. Daily rainfall followed by a strong sun when the berries are ripening and dry weather at harvest time are highly desirable. The coffee tree tolerates neither drought nor frost.

Soils must be rich and well drained. Some of the best coffee lands in Latin America and Indonesia have rich loamy soils of volcanic origin. Fully 90% of the world's coffee is grown at elevations ranging from 1500 to 6000 feet. Hilly and mountainous lands are the best sites for coffee trees, as slope land facilitates drainage, avoids excessive exposure to the sun, and affords protection against frost and wind. Windbreaks are sometimes provided to protect the trees during the blossoming and maturing period.

Most coffee trees begin to bear when they are 3 to 5 years old, but they do not produce in commercial quantities until the 6th to 8th years. Profitable yields may continue for 25 to 30 years.[3]

The growth and preparation of coffee. The coffee tree naturally grows to from 25 to 40 feet in height, but the trees are usually pruned down to from 5 to 12 feet in height to permit easy picking of the berries. The

[3] See William H. Ukers, *All About Coffee*, The Tea and Coffee Trade Journal Co., New York, 1935.

berry, which looks much like a cherry, usually encloses two coffee beans in its pulp.

After picking, the berry is put through a number of mechanical processes, the first of which takes off the outer pulp. The beans are cured, sometimes washed, and then dried. The beans may be dried in the sun, which takes a week or two, or in a mechanical drier requiring only 24 to 36 hours. Other machines then remove the two layers of inner husk, and various sortings and gradings separate the beans so that those comprising each kind of coffee are of the same appearance and size. Rather complicated machinery has been invented to do most of the coffee curing after it has once been picked by hand. This machinery is made in Europe and the United States.

Coffee production in Asia. One of the best places for the growth of coffee is found on the slopes that face the lower plain along the Red Sea in Yemen, the southern part of the Arabian peninsula, and the home of Mocha coffee. Here the shade-loving coffee tree has the advantage of a mist which arises on the lower plain almost every morning in the year and toward noon envelopes the coffee-planted slopes in a haze which keeps off the full rays of the sun and also gives the proper moisture for the good development of the plant and the production of its seeds.

The fine quality of Arabian coffee is owing chiefly to the fact that it is carefully prepared, most of the crop being bought on the trees by Turkish and Egyptian merchants who personally superintend the harvest. Aden is the port of shipment, not only for the Mocha coffee of Yemen which reaches the coast by caravan, but for large quantities of Ethiopian coffee, some of which is still picked from wild trees.

The whole of Asia and Oceania exports less than 500,000 bags of coffee a year, nearly two thirds of which comes from Indonesia (Dutch East Indies).[4] For many years Java and Sumatra were renowned for the quality of their coffee, grown in rich volcanic soils at elevations of 1500 to 5000 feet. Plant diseases and insect pests caused serious damage in the latter part of the nineteenth century, and planters eventually were forced to adopt an inferior type of coffee. The great bulk of Indonesian coffee is now used as a filler rather than for blending, because of its flat or neutral taste. Elsewhere in Asia, the principal production of coffee occurs on the eastern slopes of the Western Ghats Mountains in India.

Coffee in Middle America. Coffee is one of the best money crops for the tropic highland, and for this reason is well suited to Mexico, Central America, northern South America, and many West Indian islands. In all these regions the ruggedness of the interior makes transportation difficult; the roads are exceedingly bad; and the trail for pack animals is often the only means of access. Only valuable products can pay for such transportation, and coffee stands in a class alone when compared with such low-valued commodities as wheat, corn, beans, and wood.

Geographic and economic factors combine in an interesting way to influence coffee production in mountain districts. The elevation that produces the best coffee conditions of moisture, temperature, and slope also makes a more endurable climate that has attracted the bulk of the population of nearly all tropical American countries. Into this natural labor situation, coffee fits well with its actual and relative ease of transportation.

The Spanish-speaking peoples of Middle America frequently divide their lands into three climatic zones—*tierra fría, tierra templada,* and *tierra caliente*. The *tierra fría* (cold land) is the highest zone, usually above 9000 feet at the Equator and above 6000 feet at the Tropics. It is a land of hot sun and cool shadow, less rain and vegetation than in the lower zones, and hardier crops, such as wheat, barley, and potatoes. The *tierra caliente* (hot land) is the lowest zone and has maximum humidity and heat, supporting such crops as cacao, vanilla beans, bananas, and sugar cane.

[4] One bag of coffee weighs 132.3 pounds. Average annual exports in 1950–52 (thousands of bags): world total, 30,936; Indonesia, 314; Yemen, 75; India, 34.

Mountain view of Santos by the sea. King coffee port, pop. 120,000. Does the port business for São Paulo, pop. 2,250,000, on the cooler plateau nearby. ***Coordinator of Inter American Affairs***

Between these zones is the *tierra templada,* or "temperate" land. It has annual temperatures of 63°F. to 75°F., depending upon altitude and latitude, and the temperature seldom deviates more than 5° from season to season. Rainfall amounts to about 65 to 75 inches a year. Diverse crops are grown here, including sugar cane, tobacco, corn, and wheat. This is Middle America's coffee belt.

Mexican coffee is grown chiefly in the southern portion of the Sierra Madre Oriental and in the highlands of Chiapas to the south of the Isthmus of Tehuantepec. Coffee plantations, or *fincas,* are scattered through the highlands extending from Tehuantepec to Panama. The coffee-growing areas of Central America lie near the Pacific and have the advantage of short hauls to the sea. El Salvador and Guatemala are North America's leading coffee exporters, shipments from each country amounting to more than 1 million bags a year. Since El Salvador has no eastern lowlands to grow bananas, coffee is her one great cash crop and vital for her economy.

Coffee production in the Dominican Republic has trebled since 1935–39, exports amounting to over 400,000 bags a year, or about one half of those of Mexico. The combined shipments of all other West Indian islands are less than 50,000 bags a year. Jamaican and Puerto Rican coffees have long been known for their quality, the Blue Mountain coffee of Jamaica ranking among the highest priced coffees in the world.

The Andean highlands of Colombia, Venezuela, and Ecuador are the major coffee producers of the South American continent, with the notable exception of Brazil.[5] Colombia ranks second only to Brazil in coffee production, and her share of the world's coffee exports has increased from 4% in 1909–13 to 14% in 1935–39, and to 19% in 1950–52. Fully three fourths of Colombian coffee is grown west of the Magdalena River and south of Medellin, chiefly on the slopes of the central cordillera in the departments of Caldas and

[5] Some coffee is grown in Peru and Surinam (Dutch Guiana). Although Ecuador and Peru are mentioned here, they are not a part of Caribbean or Middle America.

Antioquia. Most of the remainder is produced on the western slopes of the eastern cordillera around Bucaramanga and Bogotá. Shipments for export move by rail to Buenaventura on the Pacific coast or down the Magdalena to the Caribbean port of Barranquilla. In Venezuela and Ecuador the coffee-growing areas lie much nearer the sea.

Brazil: the kingdom of coffee. In 1800 Brazil shipped 13 bags of coffee, and cane sugar was her great cash crop. In the 1830's coffee became the nation's leading export, and, except for a few years, it has retained leadership to the present day. By 1840 Brazil was exporting more than 1 million bags of coffee a year. Since 1850 she has usually produced more than one half of the world's coffee. Indeed, the Brazilian crop has frequently amounted to more than three fourths of the world's supply. In 1934 production in Brazil reached an all-time peak of 29½ million bags, as compared with an annual output of about 20 million bags at the present time.

About 70% of the coffee crop is grown on the rolling uplands of the states of São Paulo and Minas Gerais, nearly all of the remainder being produced in Espírito Santo, northern Paraná, Rio de Janeiro, and southern Bahia. This coffee region occupies but a small corner of a country that is larger than the United States. Indeed, the 6½ million acres in coffee trees are about equal to the combined area of New Jersey and Delaware.

The coffee-growing uplands are interlaced with railroads and modern highways that expedite the assembly of the crop. Fully three fourths of the crop moves by rail to the nearby ports of Santos, Rio de Janeiro, and Vitória for export. Santos has long been the world's leading coffee-shipping port.

The state of São Paulo is the heart of the coffee region, and the city of São Paulo (pop. 2,250,000) is its capital and economic center. The coffee plantations, or *fazendas,* are the largest in the world. Some are so large that they are served by private railway and highway systems. All are equipped with modern machinery. Coffee is grown here at elevations of 1500 to 3000 feet, the southeast trade winds bringing about 60 inches of rain a year. The area is endowed with rich, reddish soils of volcanic origin that are now declining in fertility. An occasional frost is the chief hazard to coffee production.

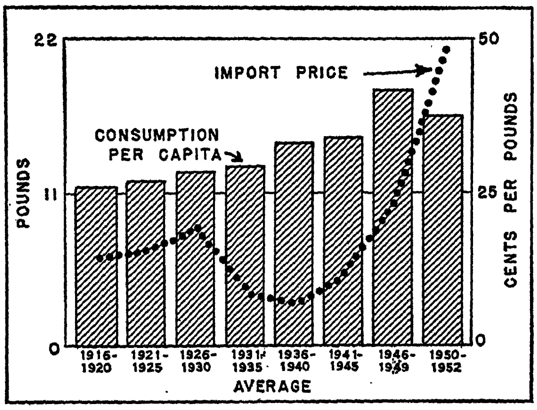
In Brazil it is common practice at harvest time to strip the trees regardless of the maturity of the berries, whereas in most other countries only ripe berries are picked, the green ones being left on the branches to ripen. The Brazilian method saves labor, but contributes to an inferior product. When an American consumer jokingly orders a steaming "cup of Java," he gets chiefly Brazilian coffee. Its flavor and aroma have been transformed to suit the American taste by the skillful blending of milder and more costly coffees that were grown in many different lands.

Brazilian coffee valorization. Throughout the nineteenth century the supply of coffee scarcely kept pace with demand, and production in Brazil was profitable. The first big coffee boom began about 1885. Land was cheap. Coffee prices were high. Profits were fabulous. Between 1890 and 1900 the number of bearing trees in São Paulo trebled as the coffee frontier rolled westward and northward. Overproduction resulted. In 1901 prices dropped, and the coffee-growing states banned the planting of new trees. This was Brazil's first valorization scheme, or attempt to raise the price of coffee.

During the present century the Brazilian coffee industry has gone through recurring cycles of boom, overplanting, glut, and ruinous price. Fear of surplus came to be Brazil's greatest fear. Bumper crops, crises, and valorization schemes followed one another.[6]

Bumper crops of 27 million bags in 1928, 28 millions in 1930 and 1932, and 29½ millions in 1934 caused coffee prices to drop

[6] See Vernon D. Wickizer, *The World Coffee Economy with Special Reference to Control Schemes,* Food Research Institute, Stanford University, Stanford, Calif., 1943, and Erich W. Zimmermann, *World Resources and Industries,* Harper & Bros., New York, 1951, pp. 385–391.



Coffee—U. S. consumption. New York price of Brazil's chief export makes Brazilian economy boom or bust. *Chase National Bank*

drastically (see Fig. 190). In the 1930's, in a world-wide business depression, Brazil again banned new plantings. Government loans were made to planters. The virtues of coffee were advertised in an attempt to stimulate demand. Vast quantities of coffee were destroyed. Some was buried, some was dumped into the sea, but most of it was burned. In 1937 Brazil finally abandoned all direct price supports but continued to burn coffee. In the decade preceding World War II, Brazil burned 68 million bags of coffee, or enough to supply the entire world for 2½ years.

An international agreement. With the wartime collapse of the European coffee market, the United States government came to the rescue. In 1940 an agreement was signed with 14 Latin American countries, regulating their shipments to the United States and to nonsignatory countries and also American imports from nonsignatory countries. This scheme, coupled with an unforeseen increase in American coffee consumption and a number of poor crops in Brazil, resulted in higher prices and a reduction of coffee in storage. In 1949, for the first time in years, Brazilian warehouses held no surplus of coffee. The spectacular rise in coffee prices since 1949 is well known to every coffee drinker.

Today Brazil has 2⅓ billion coffee trees, as compared with a maximum of 3 billions in 1933–34. São Paulo is no longer capable of bumper crops of 15 to 20 million bags. Brazil has new lands suitable for coffee production, but at higher costs—in northern Paraná, eastern Minas Gerais, central and northern Espírito Santo, and in Goiaz.[7] Granted peace and prosperity, Europe will demand more coffee. After 1960 the postwar babies in the United States will reach coffee-drinking age at the rate of 3 or 4 millions a year. Will Brazil again expand her output?

In retrospect, some Brazilian valorization schemes succeeded in temporarily raising prices. Others failed. All attempted to obtain a price high enough to make everybody happy, high-cost as well as low-cost producers. Since coffee trees need six years to achieve commercial production, all the schemes encountered difficulty in adjusting production to an uncertain future demand. And, not least, the curtailment of coffee production in Brazil stimulated production in many other lands.

The expansion of coffee production in Africa. Tropic Africa has risen to a position of importance in the world's coffee economy in a remarkably short time. Average annual exports of coffee from the African continent have increased from about 543,000 bags in 1925–29 to 2,257,000 bags in 1935–39, and to 5,268,000 bags in 1952–53. Five European colonies now account for 75% of African exports—the Ivory Coast of French West Africa, Angola, Madagascar, Uganda, and the Belgian Congo—most of the remainder coming from Ethiopia, Tanganyika, and Kenya.

The coffee-growing highlands of Ethiopia, Uganda, Kenya, and the Belgian Congo are more remote from the ocean than other producing areas, but low labor costs in production and the high value of coffee enable the commodity to stand high transportation charges en route to the seacoast. Coffee production in French West Africa, the leading area, has increased sixfold since 1939. In

[7] See George Wythe, Royce A. Wight, and Harold M. Midkiff, *Brazil: An Expanding Economy,* The Twentieth Century Fund, New York, 1949, pp. 67–68.

Angola and Uganda production has trebled. The development of coffee plantations is but one phase of the economic awakening of the Dark Continent.

2. TEA

Consumption and trade. Most of the world's tea is consumed by Orientals and by English-speaking peoples of the far-flung British Commonwealth of Nations. Tea drinking by the British is a matter of habit; by Orientals, a matter of habit and health. Oriental water supplies are usually contaminated, and the boiling of water to make tea is cheap health insurance. Tea ranks second only to plain water as a universal beverage.

The United Kingdom, New Zealand, Australia, Eire, and Canada lead the English-speaking peoples in the per-capita consumption of tea (see Table 11:2). Does the average American drink more coffee than the Englishman drinks tea? The per-capita consumption of coffee in the United States amounts to 17 pounds, as compared with 9½ pounds of tea in the United Kingdom. Consult a housewife, and we learn that a pound of coffee will make 35 to 45 cups of the beverage, while 180 to 200 cups can be brewed from a pound of tea. The Englishman wins. Indeed, it is said that battles have been halted so that Englishmen could enjoy an afternoon cup of tea.

The world's tea exports now amount to nearly 1 billion pounds a year. Tea from the plantations of the black-tea countries—India, Ceylon, Indonesia, and Pakistan—dominates the export trade.[8] Indeed, more than three fourths of all tea exports come from India and Ceylon. China, a big producer and once the goliath of the tea trade, consumes most of its tea at home.

About one half of all tea that enters into international trade is destined for the United Kingdom, which consumes more than 450,000 pounds of tea a year. About one fourth is shipped to the United States, Australia, Canada, Eire, and New Zealand. Most of the remaining fourth goes to Egypt, the Union of South Africa, French North Africa, Iran, Iraq, and the Netherlands.

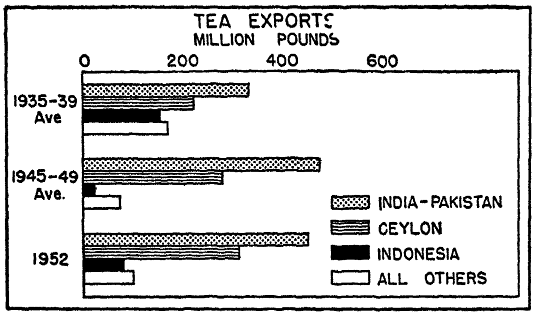
a 20th-Century Fact

The United States is the world's largest consumer of coffee and cocoa, taking approximately 60% of the coffee exported and 40% of the cocoa. The largest importer of tea is the United Kingdom, which takes more than 45% of the world export.

Thus the *Twentieth Century Fund, New York,* makes merry with Messrs. Uncle Sam and John Bull and their milder bibulous habits.

Factors affecting the distribution of tea culture. The usual tea of commerce is the dried leaf of a shrub native in the hills of Assam, one of the northern states of British India. If allowed to grow, the plant becomes a tree 25 to 30 feet high. In cultivation the shrub is usually kept down by pruning to a height of from 5 to 6 feet so that the leaves can be picked by hand. Little oil cells give the leaf its flavor. The tea shrub is quite hardy,

[8] The production and export of tea have been subject to various control schemes. See Vernon D. Wickizer, *Tea under International Regulation,* Food Research Institute, Stanford University, Stanford, Calif., 1944. The present International Tea Agreement between India, Ceylon, Pakistan, and Indonesia expires in April 1955.



Pupils of British in India and Ceylon, and of Dutch in Indonesia, have taken trade away from China and Japan. ***USDA data***

standing a frosty climate, thriving in central China and in the Cotton Belt of the United States and many other places where no tea is produced.

The distribution of the tea-growing industry gives us a sharp example of the combined working of geographic and economic forces. The large amount of skillful hand labor required in picking and preparing tea makes it necessary that tea be grown in regions of dense population with its resultant low wage. The plucking of the leaves, especially the young leaves (which make the best tea), is one of the hardest things a plant has to stand; hence the tea only produces adequately where an abundant moisture supply and a warm summer promote growth.

TABLE 11:2. Per-capita Consumption of Tea in Selected Countries
(pounds)

Country	1939	1953
United Kingdom	9.9	9.5
New Zealand	6.6	7.9
Australia	6.5	6.5
Eire	6.9	5.5
Canada	4.0	3.0
Egypt	1.1	2.1
Netherlands	3.4	1.7
United States	.7	.7
Germany	.2	.1[a]
France	.1	.1

[a] Data for West Germany.
Source: The Tea and Coffee Trade Journal Co.

The Chinese tea industry. There are no great tea plantations in China. A few trees in the gardens of many small farmers produce the crop, first for home use, second for export. The heavy rains of the summer monsoons give all southeastern Asia one of the prime conditions for the growing of tea. Most of the Chinese tea is grown in the Yangtze Valley. The mountains between this valley and the Hwang Valley are the northern limit of tea.

Chinese tea is usually picked three times a year, the first growth early in April, the second in May, and the third in July or August. The choicest first pickings are so highly prized at home that they are seldom exported; the later pickings of an inferior grade are for the use of foreigners. After the picking, which is usually done by women and children, the leaves are wilted in pans over a fire. They are next rolled into balls by hand to squeeze out the sap and dried upon screens, care being taken not to let the hot sun burn them. After this, they are further dried by "firing" in copper pans over a fire, being stirred with the bare hands. Inferior teas are stirred with sticks. After this, the leaves are hung up in sacks for a day, then picked over, sifted, assorted, and packed by aid of bare feet into tea chests for export. In some grades of tea, each leaf is rolled by human fingers.

The difference between black and green tea is merely a question of curing. Green teas are not fermented at all, the leaves being heated to prevent it, while black teas are allowed to wither and are then fermented prior to drying. Oolong teas are only partially fermented. All three types may be made from leaves plucked from the same shrub, but the curing process gives each a distinct flavor. Different regions within China specialize in the production of green, black, oolong, scented, and other teas, green teas being predominant.

In Szechwan, one of the western provinces on the Yangtze River, is a large population, estimated at over 48 million. The people have supported themselves in that inland location for generations by household industries and agriculture, and their tea yield is higher than in the other parts of China. Most of their few exports go down the rapids of the Yangtze to

Hankow and Shanghai, but into Tibet goes some of the worst tea in the world. It is made by cutting off 12-inch twigs of a tea tree, roughly drying them in the sun, chopping them up, twigs and all, sticking all together with rice paste, and then compressing the mass into hard bricks for shipment over the fearful passes of Tibet upon the backs of coolies, mules, and camels.

The greater ease of carrying this compressed form of tea accounts for its shipment by caravan into Russia at an early date. The chief seat of brick-tea shipment is Hankow. While brick tea has generally been considered of very poor quality, it has been greatly improved of late, and some of it is now made in Hankow under Russian management, great care being exercised to see that the quality is good. Unlike the Tibetan bricks, this is real tea leaf, pulverized for advantage in transport.

China remained almost the sole source of tea for the Western world until the last quarter of the nineteenth century. The development of scientifically managed plantations in other parts of Asia resulted in ruinous competition. Chinese tea exports declined from an all-time peak of 295 million pounds in 1886 to an average of 199 millions annually in 1909–13, and to 80 millions in 1935–39. China may now produce some 400 million pounds of tea a year, but her annual exports are less than 20 to 25 million pounds.[9]

Tea in Japan. Tea requires fertile but well-drained soil along with much moisture, a combination of conditions usually furnished best upon hillsides. This fact, in combination with the large amount of labor required, makes it a crop admirably suited for Japan, where the rainfall is 60 to 80 inches, and the vast demand for food causes the level land to be prized for rice and other crops and makes tea growing in terraces upon the steep hillsides fit in admirably with the Japanese economy. Tea is grown on all four main islands, but the tea for export is chiefly grown near Shizuoka. For home use the Japanese still prepare it by hand in the old-fashioned way, but for export it is almost entirely cured by machinery.

The standard Japanese teas are green, but the growers learned to prepare black tea for foreign markets. Japan now exports about 22 million pounds of tea annually, or about half as much as in prewar years.

Formosa is famous for its oolong tea. This island was ceded to Japan in 1895 as a result of the Chino-Japanese War. Tea plantations were under strict governmental control during the Japanese regime, and the quality of the tea was greatly improved. Under the present Chinese Nationalist regime, tea exports have occasionally exceeded their prewar average of 23 million pounds a year.

The tea industry of India and Pakistan. India is the world's largest producer of tea. Its 780,000 acres in tea yield more than 600 million pounds of dry tea a year. More than four fifths of the crop is produced in the Assam and Darjeeling-Dooars districts along the southern slopes of the Himalaya Moun-

Nursery of tea trees, grown in cylinders of earth ready to transplant. *Information Service of India*

[9] Among the causes contributing to the decline of Chinese tea exports were backward methods of cultivation on small and scattered landholdings, the poverty of the farmers, the lack of knowledge and desire to improve the quality of the tea, and a multiplicity of local taxes upon tea. Taxes and graft have long retarded the movement of commodities in China, land of the itching palm.

tains. This region receives tremendous summer rains, tea being grown on well-drained soils at elevations of less than 3500 feet. Most of the remainder of the Indian crop is grown on the Nilgiri Hills in the southern part of the country, and, because of low latitude, tea does best here at elevations of 4800 to 5600 feet. Tea is also produced in the northern part of East Pakistan, where the crop amounts to about 40 to 50 million pounds annually.

Indian tea plantations vary from less than 100 acres to nearly 6000 acres. The larger ones were started by British enterprise years ago and are well managed. Tea is picked about every 10 days during the monsoon rains, which occur in the warmer half of the year. The large Himalayan crop makes Calcutta the world's leading tea-shipping port.

Tea production in Ceylon. In 1867 Ceylon had only 10 acres planted in tea. In 1873 its first exports consisted of a small sample of 23 pounds. Today its plantations occupy about 560,000 acres and yield over 300 million pounds of dry tea a year, Ceylon ranking second only to India in the export of tea (see Fig. 192). Colombo, the chief port, is surpassed only by Calcutta in volume of tea shipments. This mountainous island has an outstanding advantage in production: it has no dry season, and tea can be picked about every two weeks throughout the year. Ceylon produces some of the world's best tea.

The Ceylonese method of tea growing is typical of the most successful method of prosecuting tropical industries. More than half of the plantations are owned by corporations, and practically all are managed by British superintendents. The average plantation is about 200 acres in size. Nearly 350 plantations exceed 500 acres in size, but three fifths of all tea estates occupy 10 to 100 acres.[10] Work on the Ceylon tea plantation is done by coolies—men, women, and children—many of them being Tamils from southern India, who usually return to their homes across the straits after a period of work gives them a little money. Tea cultivation is an intensive user of labor, and in Ceylon wages account for 70% of production costs. Throughout the Far East tea production and high population densities go hand in hand.

Tea in Indonesia. Most of the tea of Indonesia (Netherlands East Indies) is grown in western Java to the south of the capital city of Jakarta (Batavia) and in northern Sumatra to the south of the port of Medan. Both islands have abundant rainfall and a continuous harvest of tea. Java has a population density of about 1000 per square mile. Its tea production is about five times larger than that of neighboring Sumatra. The tea districts are from 2000 to 5000 feet above sea level, with most of the estates on the slopes of the volcanic mountains.

Indonesian farmers have generally followed the wise policy of first growing enough food to feed themselves before planting land in cash crops. Furthermore, the natives do not put all their cash crops in one basket. They grow sugar cane, rubber, coffee, tobacco, cinchona, and other cash crops as well as tea, thereby avoiding the dangers of superspecialization. Virtually all the tea in Sumatra is grown on plantations, but in Java about two fifths of the crop is produced by the natives on their small farms.

Other tea-growing districts. Africa exports 30 to 35 million pounds of tea a year, or about twice as much as in prewar years. Two thirds of all exports come from Nyasaland and Kenya, the remainder being shipped chiefly from Tanganyika, Uganda, and Mozambique. Other exporters are Malaya and Brazil. Iran produces more than 10 million pounds of tea annually, chiefly on the slopes of the Elburz Mountains, but the nation remains dependent upon imports. These countries have low labor costs, a decisive factor that prohibits tea culture in southern United States.

---

[10] See International Bank for Reconstruction and Development, *The Economic Development of Ceylon*, The Johns Hopkins Press, Baltimore, 1953, pp. 227–235.

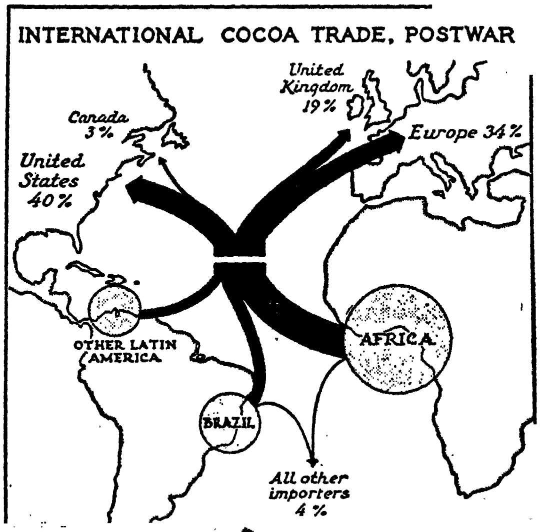
In 1935–39 the Soviet Union produced 15½ million pounds of tea annually, and its imports averaged 41 million pounds. Production occurs chiefly on the moist hills east of the Black Sea near Batum. Reliable postwar data are not available.

Other teas. The leaves of a number of other plants are locally used as tea in various places throughout the world. In southeastern United States the Cherokees and other Indians dried the leaves of a holly plant from which they made yupon, or "black drink." In Australia the eucalyptus leaf is used; South Africa has a so-called "Bushman tea"; a grass called lemon grass is used in India; while in the Island of Bourbon or Reunion in the Indian Ocean, the so-called "bourbon tea" is made from a dry orchid.

Of all the minor teas the yerba maté or Paraguay tea is the nearest to being a rival of the ordinary tea of commerce. This plant, which is a member of the holly family, grows wild in southern Brazil, northern Argentina, southeastern Bolivia, and most of Paraguay. It is now being successfully grown on plantations, and mechanical processes of curing and drying insure uniformity. Summer rains of the maté belt favor the rapid leaf growth necessary for such a crop. Unlike tea, the bright green maté leaves are not picked by hand, but the branches are lopped off the bushy trees and smoked over fires until the leaves are dry enough to crumble into powder. The beverage is widely used by the peoples of Argentina, Paraguay, Uruguay, and southern Brazil. Indeed, Brazil exports more than 100 million pounds of yerba maté a year, almost entirely to the Argentine market.

3. CACAO

The confusion of names. Chocolate and cocoa are manufactured from the beans of the cacao tree which, because of its name, often gets confused with the coco palm that gives us the large, hard-shelled coconut (often spelled cocoanut). It is also confused with the coca tree, the leaves of which are sent to market from the east slopes of the Andes in Peru and Bolivia by way of the Amazon River or the Pacific ports for the preparation of the drug, cocaine. It has nothing to do with Coca-Cola and other cola drinks that are made from an extract of coffee and kola nuts, grown in tropic Africa, the West Indies, and Brazil. The word *cacao* here refers to the cacao beans that are obtained from the pods of the cacao tree.[11]



Africa has cheap labor. ***Courtesy of V. D. Wickizer and Stanford Univ. Press***

Origin and early use. The cacao tree is a native of tropical America, growing wild in the forests of lowland Mexico, the Amazon valley, and other hot and humid regions, up to an elevation of 400 feet. At the time of the discovery of America, it was grown from Panama to Guatemala and Yucatan, and to some extent in the lowlands of Mexico, in which country it was so prized that the dry beans passed as money among the Aztecs of the plateau. Cacao beans were exported from the New World to Spain and Portugal, where the use of cocoa as a beverage became popular and soon spread to other European lands.

[11] The words *cacao* and *cocoa* are used interchangeably in many books as well as in business. The tree, pods, and beans are often called cocoa. The New York Cocoa Exchange deals in the purchase and sale of cocoa (cacao) beans.

Consumption and trade. In contrast with tea and coffee, cacao has great food value and a variety of uses.[12] About half the cacao bean is fat, which never becomes rancid no matter how long it is kept. Cocoa, the beverage material, differs from chocolate by having a part of the fat removed to make it more easily digestible. Chocolate supplies four times as many calories as eggs and three times more than meat (see Table 12:1).

The confectionery, ice cream, baking, dairy, and soft-drink industries use cocoa butter, cocoa powder and paste, chocolate, and chocolate syrups in the manufacture of a great variety of foods and beverages. Cocoa butter is commonly used as a base for cosmetics and in various pharmaceutical preparations. Cacao owes much of its popularity in this country to the great American "sweet tooth," particularly the use of chocolate in candy, ice cream, sodas, sundaes, milk shakes, chocolate milk, and other tasty things.

All processes of manufacture merely grind up the red-colored cacao beans. This grinding may be done in the kitchen, as do the Chinese cooks in the Philippines who pound the beans in mortars and flavor them with spices to suit individual tastes. In the Western world the beans are taken to large factories, where expensive machinery pulverizes the beans to great fineness, mixes the powder with sugar, various flavors, natural or synthetic, and sometimes also with milk. The use of milk requires many chocolate factories to be in or near dairy districts, as in Switzerland, the Netherlands, the United Kingdom, and eastern United States.

The United States and the United Kingdom far surpass other nations in the total importation and use of cacao beans (see Table 11:3). The Netherlands (pop. 10,426,000) ranks first in the use of cacao per capita, largely because this little trading nation is able to export annually more than 60 million pounds of cocoa butter, cocoa powder and paste, and chocolate worth over $45 million.

TABLE 11:3. Apparent Consumption of Cocoa in Selected Countries in 1953

Country	Total consumption[a]	Per-capita consumption
	Metric tons	Pounds
Netherlands	70,000	14.8
United Kingdom	120,000	5.3
Switzerland	8,000	3.7
United States	260,000	3.6
Canada	14,000	3.6
Germany, West	65,000	3.0
Belgium	10,000	2.5
France	48,000	2.4
Sweden	7,000	2.2
Australia	8,000	2.0

[a] Net Imports.

Source: Total consumption data from Commodity Research Bureau, New York. Per-capita data computed by authors.

The chief commercial supply of cacao has shifted from time to time. At first it was Mexico, next Venezuela from about 1750 to 1850, then Ecuador until World War I, then briefly Brazil, and lastly the European colonies along the Gulf of Guinea in West Africa, where very cheap labor abounds. In 1952 West Africa provided about 75½% of the world's cacao exports; Latin America, about 23½%; and Asia and Oceania, less than 1%. The Gold Coast and Nigeria together account for more than one half of the world's cacao exports and are followed in importance by Brazil, the Ivory Coast, and the French Cameroons (see Fig. 195).

Exacting climatic requirements. The climatic requirements of cacao are exacting. The tree, which is 15 to 40 feet high, requires more heat than coffee and yet cannot stand the full blaze of the tropic sun. So it is grown under the shade of taller trees, the young plantation being sometimes shaded by corn or bananas. It requires much moisture with soil rich and deep, so that it is almost always grown upon low plains.

The valuable beans, to the number of 30 to 60, are produced in a greenish or reddish pod, 3 to 4 inches in diameter and 6 to 10 inches long. Because this heavy, cucumber-shaped fruit is attached in clusters to the trunk and

[12] For an excellent discussion of the three commodities, see Vernon D. Wickizer, *Coffee, Tea, and Cocoa: An Economic and Political Analysis,* Stanford University Press, Stanford, Calif., 1951.

larger branches of the tree, and because a strong wind beats the immature pods about until they fall useless to the earth, the area over which cacao can be a profitable crop is greatly limited. In regions of tropic typhoons (hurricanes), or even where strong winds blow, the cacao tree cannot be depended upon as a source of financial income. This affects most of the West Indies, where cacao can be grown only in valleys protected from the wind —as in rugged parts of Trinidad, Jamaica, Grenada, St. Lucia, and the Dominican Republic. A level island exposed to the steady trade winds, such as Barbados, cannot produce it.

Near the Equator in all continents is a zone of calms, called doldrums, lying between the two trade-wind zones and drenched with frequent and heavy rains. In this belt, at no place more than 13°N. or S. Lat., are found the most important cacao districts.

The cacao tree thrives in humidity and heat. It begins to bear at the age of three years but does not reach maturity until it is 10 or 12, and it may bear for 30 or 40 years more. At harvest time the pods are severed from the tree by means of a knife, perhaps a long pole. They are cut open, and the beans, which are covered by a slimy pulp, are taken to the sweating house for fermentation. In the course of a week this process disposes of the pulp, and the beans are then ready for drying in the sun or a mechanical dryer. When carefully fermented, the beans are twice as valuable as when carelessly done.

Cacao production in Latin America. As late as 1900 tropic America grew four fifths of the world's cacao, and at the outbreak of World War I Ecuador still led the world in production. In 1916 the Ecuadorean cacao trees were attacked by the monilia disease, and in 1922 by the witches' broom disease. These disasters, together with careless management of the plantations and a high export tax on cacao exports, caused the Ecuadorean industry to decline. Although cacao thrives on the hot sun and humid plains along the Gulf of Guayaquil, the Ecuadorean crop is now

This cocoa tree with fruit shows why the grower chooses windless locations. *Ecuadorean Embassy, Washington, D. C.*

one third smaller than in 1909–13, and the nation supplies only 4% of the world's cacao exports. The monilia disease spreads, giving a duplicate of the banana troubles.

Brazil produces more than one half of all cacao grown in Latin America. The Brazilian cacao belt is about 360 miles long and 9 miles wide, being located in the rainy state of Bahia at a short distance from the seacoast. Cacao for export is shipped by coastwise steamers from Ilheos and other ports to Salvador, the great primary market and exporting port. Brazilian exports averaged 213 million pounds in 1950–52, as compared with 264 millions in 1935–39.

Venezuela ranks fourth among Latin American cacao producers, being surpassed by Brazil, the Dominican Republic, and Ecuador. Most of the Venezuelan crop is grown in the Maracaibo Basin and in the valleys of the eastern Andean highlands. In the Dominican Republic four mountain ranges and three intervening valleys extend across the country in an east-west direction. Most of the nation's cacao is produced in the rainy eastern end of these intermontane valleys.

In Brazil, Ecuador, and much of the Caribbean region cacao production tends to be a

plantation industry. Most plantations have a few hundred thousand trees, although a few have a million or more. In addition, many small native farms are engaged in the production of cacao.[18]

Cacao production in West Africa. In contrast with Latin America, where plantations are common, the production of cacao in West Africa is distinctly a small-scale native enterprise. Nearly all the cacao of this region is produced on farms of less than 5 acres. Thousands of African patch farmers have a few acres in cacao trees. Labor is abundant and very cheap. The man who works for himself has no payroll to meet, and he was not brought up in a money economy. This accounts for the low costs of the West African cacao industry.

The spasmodic labor of cacao growing suits the tropic denizen. There is no rush to market as in bananas. No big organization is needed. The dried beans keep well. There is no expensive machinery to clean as in coffee. Take a basket of cacao fruits, sit on your heels, cut the cacao open with your machete, pick out the beans with your fingers, put them in a pile to ferment, dry them on a bamboo tray which you yourself have made. If rain threatens, carry the tray into your grass house. You soon have a hatful of beans to sell or eat, even if you don't have a hat to put them in.

Colonial governments have built some new highways, and in a few areas the motor truck has appeared. Beans from the back country, however, usually move to the nearest railroad or waterway by porter trains, consisting of long lines of Negroes carrying baskets of beans on their heads.

The Gold Coast supplies nearly one half of all cacao exports from West Africa, and Nigeria, one fourth. The remainder comes chiefly from the Ivory Coast and French Cameroons, with lesser amounts from the islands of Fernando Po, São Tomé and Principe, and from French Togoland.

The Gold Coast is by far the world's leading cacao exporter, although its average annual exports declined from 609 to 527 million pounds between 1935–39 and 1950–52. Annual exports from all West Africa average about 1025 million pounds, or slightly less than in prewar years, which may indicate that production along the Gulf of Guinea has about reached its peak.

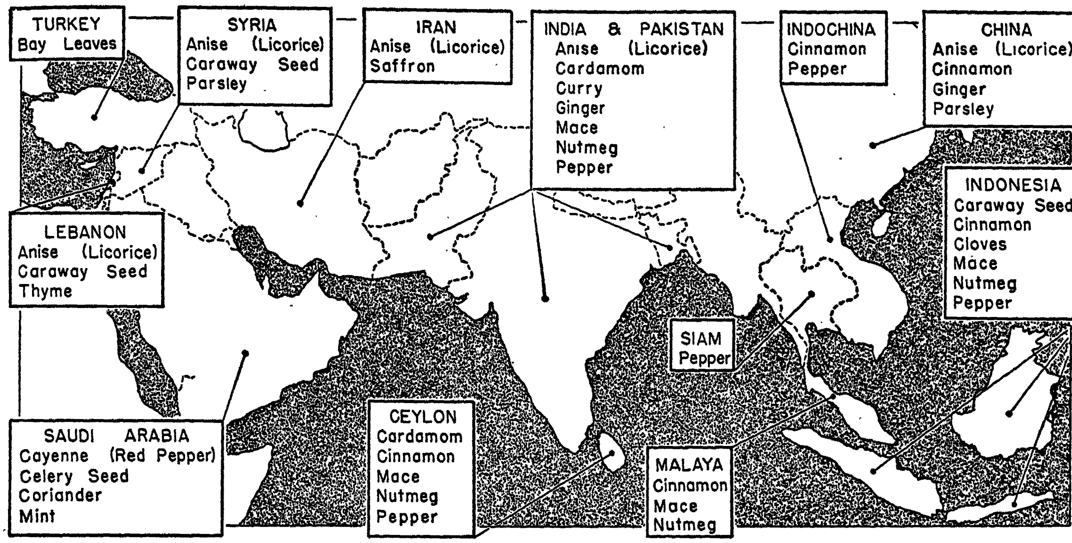
[18] *Ibid.*, p. 276.

4. SPICES

Early demand for spices. Despite their nonnutritious character, spices are so generally prized as an article of diet as to be of nearly world-wide demand. In the history of commerce they are of especial interest because the trade in spices long dominated the commerce between the East and the West. They were for centuries the only food products that could be transported far, and they were of greater relative importance in the diet of ancient and medieval peoples because the small variety and poor flavor of their food made a greater necessity for something to improve its palatability.

The product of tropic garden spots and hives of population. Practically all the spices, with the exception of mustard, are limited in their production to the tropics. The trees and fruits from which they are produced have been widely disseminated throughout the hot countries, their growth is usually common, but the commercial production of the spice rarely follows the mere introduction of the plant for local use. This is owing to the fact that nearly all the spices are like tea in requiring tedious and painstaking labor in their production. As a result their export is limited to centers of dense population and good labor supply. It was the spice trade that Columbus sought, and spice trees were among the early introductions to the New World. While the New World gave the Old World grains and cattle and now dominates in the export of these products of sparse populations, our export of spices yet remains insignificant.

Pepper. This is the most important of all spices. It is prized alike by rich and poor in both tropic and temperate latitudes. In quan-



This map tells much. ***Aramco World***

tity it equals all the others combined. The United States imports about 10,000 to 15,000 tons of pepper a year. About 80% to 85% of our imports come from India, and most of the remainder is obtained from Indonesia. Only small amounts are now purchased from Malaya, Thailand, and other countries.

Black pepper is the dried, unripe seed of a climbing vine, and white pepper is the same seed riper and with skin peeled off. The common method of growing this plant is to sow the seeds in fields of rice, castor beans, and other temporary crops. At the same time the seeds of rapidly growing trees are sown. In two years these trees are cut and stuck in the ground as poles, making a permanent support for the climbing pepper vine, which yields its crop after a three-year wait and is expected to produce for 10 years.

Cayenne pepper or chilies is an entirely different plant, yielding a small fruit something like the peppers commonly seen in temperate-zone markets. It is widely grown for local use throughout tropic Asia and Africa and in South America, and properly takes its name from the city in French Guiana.

Ginger. This, the second spice in the order of demand in the market, is the underground stem of a reedlike plant that grows wild in the warm parts of Asia. It is today one of the most widely cultivated spices. Planted like any common crop, ginger is dug in 10 months, and, like most spices, it is dried in the sun. Today ginger is exported from British West Africa, China, Jamaica, and British India.

Cinnamon and Cassia. Cinnamon is the bark from young shoots of a small evergreen tree native to Ceylon and the adjacent coasts of India. It was a government monopoly in Ceylon until 1833. Ceylon, with 33,000 acres under cultivation, produces most of the world's supply, minor production occurring in Java and the Seychelles Islands northeast of Madagascar. The island of Ceylon has the necessary warmth, moisture, and light sandy soil, and a population density of 320 per square mile—thus the labor necessary to keep cinnamon trees trimmed to a low bushlike form, to gather the long shoots, peel the bark from them, and dry it ready for the market. The flavor of cinnamon, like most of the spices, is due to an essential oil. Cassia, the bark of a somewhat similar plant, is much like cinnamon, is gathered in the same way but is of inferior quality, and is largely used to adulterate the Ceylon article. Most of the cassia is produced in the tropic part of south China, and the exports are sent out through Hong Kong.

Nutmegs and mace. Mace is the husk around the nutmeg, the fruit of a tree growing wild in the Banda Islands in the East Indies. This spice tree, with the clove, was long a monopoly of the Dutch government in the Moluccas or Spice Islands, where the Dutch traders in the days of their commercial supremacy preserved their spice monopoly by sailing the eastern archipelagoes and cutting down spice trees wherever they found them. Nutmegs and mace are now chiefly grown for export in Indonesia and the islands of Penang (110 square miles, 2391 people per square mile) in the Strait of Malacca, and in Grenada, West Indies (120 square miles, 547 people per square mile).

Cloves. This hot spice is the dried unopened flower bud of a tree grown chiefly (85% of world supply) in the islands of Zanzibar and Pemba off the eastern coast of Africa (total area, 1020 square miles; population, 230 per square mile). The plantations are owned mainly by Arabs. These islands, with 3½ million trees in bearing, produced over 29 million pounds of cloves in 1951. The oil of cloves is often extracted from the spice and sold as a separate product. Madagascar is the only other important producer of cloves.

Vanilla. The vanilla bean is a native of Mexico. About half the world's crop is grown in Madagascar, the remainder being produced in French Oceania, eastern Mexico, and Reunion Island, with small amounts in the West Indies.

The growth of vanilla is very exacting. It is an orchidlike vine and must grow in the shady and humid forests. Owing to a peculiarity of the blossom, each one must be fertilized by means of a small splinter of wood in the hand of the attendant. After the beans are ripe, they must be carefully dried to maintain the perfect flavor. The chemists now make a good coal-tar substitute.[14] Vanilla is not a spice but is an important flavoring extract that renders the same service.

Pimento or allspice. This fragrant spice is the small, dried and wrinkled fruit of a beautiful tree which grows to 30 feet in height, is a native of tropical America, and is cultivated chiefly on the mountainous island of Jamaica (324 persons per square mile). The pimento tree commonly grows in pastures, and at picking time small boys climb the tree and break off the fruiting twigs. Women pick these up from the ground and attend to the work of drying and preparing the fruits for market.

Mustard. Mustard is the most popular and extensively used spice in Great Britain, and is quite generally used in other countries. It is the finely powdered seed of a plant belonging to the same family as the turnip and beet. The production of this seed is quite well scattered, and seems to be centered in localities possessing the necessary foggy climate that favors its best development; thus certain foggy districts in Essex and Cambridgeshire, England, and in Holland have developed a mustard industry.

In 1950-52 American mustard-seed production averaged about 17 million pounds a year, as compared with annual imports of 25 million pounds. Montana produces about 95% of our domestic supply; California, nearly 5%.

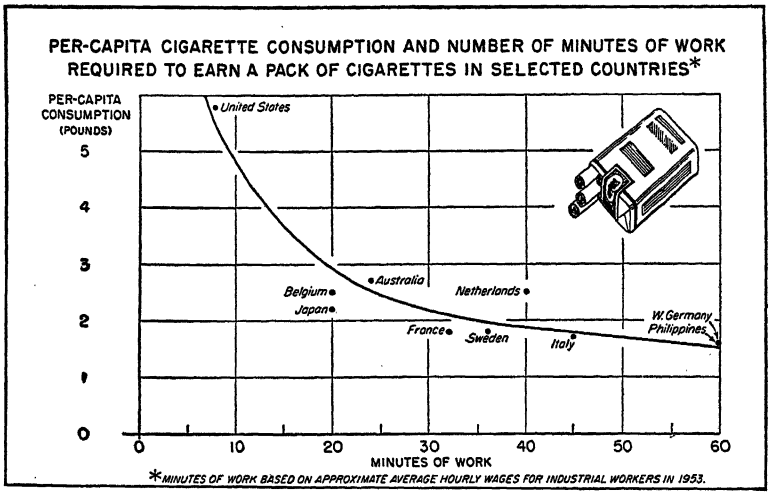
An inferior quality of mustard is also exported from Bombay, India, where the climate renders the seed too hot to be generally acceptable.

5. TOBACCO

The consumption of tobacco. No textbook for use in Europe or America need tell of the uses of tobacco, except to refer to the industrial services, such as the utilization of tobacco waste as insecticide and as fertilizer rich in potash. Columbus and his fellow discoverers found tobacco in use among the American Indians. When carried back to Europe, its use was opposed by priest, pope,

[14] The natural vanilla flavor is produced by vanillin and other substances in the bean. Synthetic vanillin is made from oil of cloves, hardwood tar, wood-pulp waste. This laboratory vanillin is sweeping the market. It promises to do to the natural product the same thing that laboratory blue did to the natural indigo industry—send it to oblivion.

The minutes of work depend on wages and taxes. Tobacco is often heavily taxed. *U. S. Department of Agriculture*



king, and emperor, and the czar of Russia once laid even the death penalty upon its use. Doctors and athletic coaches oppose it, but nonetheless its use has spread faster and farther than any language or religion and is found throughout the realms of civilization and barbarism.

Tobacco really took possession of this nation when the machine made cigarettes by the mile and cut them off in lengths, and the advertisers, discovering that we were but guinea pigs, took charge of our habits. The increase in number of cigarettes manufactured has been little less than astronomical—1 billion in 1885, 18 billions in 1914, 181 billions in 1939, and 431 billions in 1953. Indeed, per-capita consumption by persons 15 years of age and over amounted to 3900 cigarettes in 1953, or 6½ times more than in 1920. It is estimated that in 1954 approximately 70% of all men and 40% of all women were smokers, as compared with 50% of the men and 20% of the women in 1935.[15] No nation rivals the U. S. in the manufacture and use of tobacco.

Characteristics of leaf-tobacco production. Few commercial plants grow over so wide a range of the earth's surface. The tobacco plant is injured by frost, but it grows in a comparatively short season, so that profitable crops ripen as far north as Wisconsin, southern Canada, and England, while it is at home throughout the tropics. Indeed, tobacco production extends from 52° N. Lat. in England and 45° in North America to 40° in the Southern Hemisphere.

Although tobacco is grown in at least 64 countries, more than 50% of the world's crop is produced in the United States, China, and India.[16] These three leading producers are now followed in importance by the Soviet Union, Japan, Brazil, and Turkey.

Probably no other commercial product possesses more grades and commercial varieties. One field of Sumatra tobacco may be classified into as many as 72 different market kinds. The quality of the soil affects the quality of the tobacco in a remarkable degree, as does temperature, humidity, the seed, the method of cultivation and fertilization, and especially the fermentation and chemical changes that take place in the process of curing the leaf. The green leaf is cured in barns on the farm and then, for some uses, is cured in hogsheads for a year or two or three. The resulting strength or weakness of flavor, the kind of flavor, the thickness, brittleness, elasticity, texture, color, size, perfection and relative weight of leaf, its specks, its dustiness, gumminess and ripeness are factors that shift tobacco price from 2¢ to $2 per pound.

[15] "Cigarettes—Their Production and Use," *The New York Times,* June 27, 1954, Section 4, p. 8.

[16] Annual average production, world and leading countries, millions of pounds, USDA data:

	1935–39	1953–54
World	6491	7611
United States	1460	2107
China	1255	1335
India	761	557

A double-decker belt conveyor behind the workers—top carries in empty cartons, bottom carries full cartons away. Machine counts cigarettes, packs and closes carton. A machine, not shown, makes continuous cigarette and chops off 20 smokes a second. *R. J. Reynolds Co., Winston-Salem, N. C.*

Tobacco injury to American soils. In pioneer days tobacco was one of our chief exports to Europe. Profits were big, and many a farmer planted his fields in tobacco year after year, seldom allowing the land to lie idle or fallow. Few men tried to improve their land as did that progressive farmer, George Washington. When tobacco's great demand for potash exhausted the soil—and potash could not be bought—the field was often abandoned because land was so cheap that more could be had by cutting down and burning the forest. Then the heavy downpours of the summer thunder showers sometimes reduced the naked tobacco field to useless gulleys before the briars and old field pine could again make a forest there. This wasteful policy brought great poverty to southern Maryland and middle Virginia; and from these sections the people emigrated in such large numbers shortly after the Civil War, when western farm lands were opened up, that there was a general loss of population throughout the old Colonial tobacco district, which today has fewer people and less land in cultivation than it had a century ago.

As regards potash, tobacco is the worst of soil robbers, although the destruction of soil fertility does not necessarily follow if proper crop rotation is practiced. This has been proved in many places, notably by the farmers of Lancaster County and other parts of Pennsylvania. Here splendid crops of tobacco are grown on small farms producing corn, wheat, clover, and cattle, the tobacco being grown on the same land only once in a period of six or seven years. For the three years 1921-23 the average yield per acre in Pennsylvania was 1360 pounds; in Virginia but 680 pounds.

Table 11:4 suggests that Virginia has become more careful and has applied more fertilizer. Table 11:5 suggests that the soils of Massachusetts, Connecticut, New York, and other eastern states are in better condition today than when the forests were first cleared by the pioneers, as a result of the use of commercial fertilizer, crop rotation, and other

TABLE 11:4. Yield per Acre of Five Leading Tobacco-producing States Ranked by Production
(pounds)

State	Yield per acre, 1941–50 av.	Production 1941–50 av.
North Carolina	1118	736,834,000
Kentucky	1110	397,950,000
Virginia	1120	138,489,000
Tennessee	1182	128,139,000
South Carolina	1134	128,052,000

Source: USDA, *Agricultural Statistics, 1953.*

TABLE 11:5. Yield per Acre and Total Production of Tobacco in the Five States Having the Highest Yield per Acre
(pounds)

State	Yield per acre, 1941–50 av.	Production 1941–50 av.
Massachusetts	1566	10,694,000
Wisconsin	1469	32,468,000
Pennsylvania	1448	50,451,000
Connecticut	1366	24,416,000
New York	1348	980,000

Source: USDA, *Agricultural Statistics, 1953.*

scientific farming practices. The tables also show a situation that is very common with major crops—high yields and heavy production occur in different places.

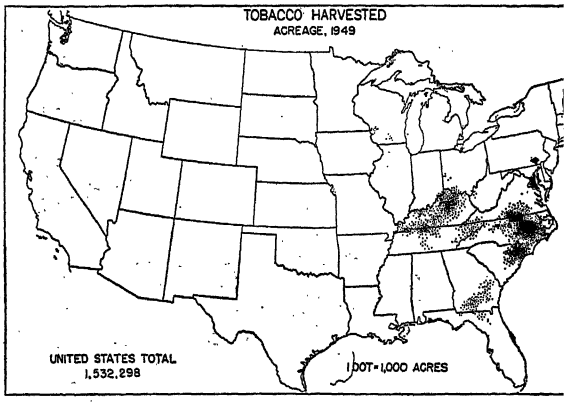
An intensive crop. Because of the great amount of labor in its production, a pound of tobacco is worth many times as much as a pound of hay or grain. It belongs to intensive agriculture (see Table 11:6). The tiny black seeds, 300,000 or 400,000 to the ounce, are sown in seed beds, and until the invention of a planting machine in this century, the little plants were transplanted by hand to their place in the field. There constant attention and hand labor are still necessary to protect them from the cut worm (which cuts off the young plant), the leaf worm (which eats holes in the leaves), and the stalk worm (which destroys the central stalk of the plant). The blooms must be picked off, so that the energy may go to leaf rather than seed. For the same reason, the suckers or side shoots must be pulled off.

The process of picking, curing, sorting, grading, and packing tobacco is laborious and requires skill. As much of the labor of tobacco growing requires watchfulness and care rather than strength, it can be done by women and children as well as by men; and as a result tobacco is rarely grown on an extensive scale and is usually raised by the members of the farmer's family (often tenants), who care for a small field. The tobacco farmer of Virginia and Kentucky usually grows enough corn to feed the horses that work his lands, the pigs that make his meat, and the cow and chickens that help feed the family. He sometimes also raises some other supply crops, but all his money he usually

TABLE 11:6. A Comparison of the Tobacco, Wheat, Hay, and Corn Crops of the United States, 1952

Crop	Farm value per acre	Acres harvested	Total farm value
Tobacco	$636.45	1,773,000	$1,128,320,000
Wheat	38.24	70,585,000	2,699,275,000
Hay	34.65	74,664,000	2,586,916,000
Corn	61.48	81,359,000	4,996,079,000

Source: USDA, *Agricultural Statistics, 1953.*



A crop of marked concentration not primarily dictated by climate. ***U. S. Bureau of the Census***

expects to get through the sale of tobacco. From the social standpoint, this share-cropper system leaves much to be desired.

The leading tobacco belts of the United States. For a long time the Virginia–Carolina tobacco belt, running from southern Maryland through the middle part of Virginia and North Carolina and on into South Carolina, has been the leading tobacco belt of the United States.

The limestone lands of Kentucky are the chief seat of tobacco production, which makes Kentucky the second state. Lexington, Ky., is the largest loose-leaf tobacco market in the world. It is brought to great auction rooms by the growers. Wilson, N. C., is the greatest fine-cured tobacco market. Much Kentucky tobacco is exported to European countries, and large amounts of tobacco are warehoused and manufactured in Louisville. In the eastern field, Richmond, Va., is the greatest center, while Petersburg, Va., and the Carolina towns of Wilson, Winston-Salem, and Durham are leading tobacco markets. Winston-Salem and Durham have enormous tobacco factories where, by very complicated machinery, cigarettes, smoking and chewing tobacco, and snuff are manufactured for shipment to all parts of the United States and for export.

The minor tobacco belts of the United States. The growing of tobacco is widely scattered in this country, small but important tobacco-growing districts being found in the

This Cuban tobacco field has thin cloth cover to change climate a bit and the quality of tobacco. Done in many areas. ***Cuban Embassy, Washington, D. C.***

Connecticut River Valley of Connecticut and Massachusetts; in southern Wisconsin; in Louisiana, where the famous "perique" is grown; and, since 1884, in Florida. Experiments with the seed of the high-priced Sumatra tobacco showed that with shade it would grow well; consequently fields are so planted that thin cotton sheets can be placed over them to soften the rays of the sun and make a more even temperature and more uniform humidity. Despite this great expense the business has proved profitable in Connecticut and Florida. Cuban tobacco as well as the Sumatra has been grown in Florida, and the artificial shade method has been copied in Cuba and Puerto Rico. The effect of these innovations is shown by the fact that the average price of Connecticut tobacco during 1941–50 was 93¢ per pound, while the huge Kentucky crop averaged only 40¢ per pound.

Our import needs. The fact that the United States is today the world's largest producer and leading exporter of tobacco does not mean that we supply all the requirements of our own people. We are large importers of three distinct classes—cigar tobacco, coming mainly from Cuba and Puerto Rico; wrapper tobacco, coming from distant Indonesia; and certain types of cigarette tobacco, coming chiefly from southern Europe and the Near East.

Tobacco in Cuba and the West Indies. Cuban tobacco is famed throughout the world for its fine flavor, being much prized for cigars and used chiefly in the manufacture of the famous Havana cigars. The Cuban crop averages about 77 million pounds a year. The Havana tobacco is the peculiar product of the south slope of the Sierra de Los Organos, a mountain range running from east to west throughout the whole length of the province of Pinar del Rio in the west end of Cuba. Tobacco is the one means by which the people of this district, called the Vuelta Abajo, are now able to buy products of the entire world. Innumerable attempts to grow the same tobacco in other parts of Cuba and other countries have resulted in failure, the nearest approach to success having been the shade-grown Florida product. The secret of its high quality is not known. It may be the protection from northern winds or some quality of soil or some effect of fermentation in curing. Most of the Cuban tobacco is used for cigars, and Havana is a great cigar-manufacturing center.

Tobacco is also exported from Puerto Rico and from the Dominican Republic.

Tobacco production in Asia. About 2.7 billion pounds of tobacco are produced on the continent of Asia each year, or slightly more than in North America. China, India, Turkey, Japan, and Pakistan are the leading producers, accounting for about four fifths of the continent's total supply. Few countries have a surplus for export, notably Turkey, India, Indonesia, and the Philippines.

Sumatran tobacco is like the Cuban in being of high value. Its thinness and elasticity give it great excellence as cigar wrappers, while the Cuban excels as cigar filler. This Sumatran tobacco belt lies on the eastern plain extending 5 or 10 miles inland from the Strait of Malacca. In 1952 Java and Madura produced nearly 100 million pounds of tobacco, or four times more than Sumatra. Only one fourth of Indonesian tobacco is grown on plantations or estates, the remainder being produced on the small farms of the natives.

The Philippine tobacco bears the same repu-

tation in the Eastern world that the Cuban tobacco does in the Western, and the export nearly equals that of Cuba. The best of it is grown in the northern province of Luzon in the valley of the Cagayan River, which keeps the tobacco lands perpetually fertile by the layer of mud deposited in the annual overflow. This tobacco is shipped from the port of Aparri to Manila, where many persons are employed in making it into the well-known Manila cigars.

European and North African tobacco production. Tobacco is grown in many other parts of the continent of Europe, but because of large population, the quantity is usually insufficient for local use. The Soviet Union, Italy, Greece, and France lead in production.

Nearly all the Danube Basin and Balkan countries are tobacco growers; it is an important crop in Hungary, Bulgaria, and Yugoslavia, as well as Greece. Some of the choicest grades of Turkish tobacco are raised in the provinces of Bosnia and Herzegovina in Yugoslavia; wherever a small patch of level ground can be found among the limestone sinks, soil is collected and protected from erosion by stone barriers. Greece is the only important European exporter, her mild-flavored Turkish tobacco, grown largely on the plains of Thessaly, going to Germany, to the United States, and to Egypt to be used in cigarette making.

The so-called "Egyptian" cigarettes, one of the principal manufactures of Cairo, are made entirely of imported tobacco. The growing of tobacco is prohibited in Egypt, and she must depend on Greece and the Near East for her raw material.

France is fostering tobacco growing in her African colony of Algeria, and the export of Algerian tobacco is increasing.

South American tobacco. Brazil grows enough tobacco along her eastern coasts for her own large home consumption and an export of 60 million pounds that makes her the sixth tobacco exporter of the world. Ninety per cent of the export is shipped from Bahia, where the foreign commission houses advance the

Drying tobacco on Padang Highlands of Sumatra, Indonesia. Grass roof and coconut trees in background. ***Wm. H. Koenig***

money to the growers, who are often in debt, and take the crop in payment for the loans.

Colombia has a small tobacco export which is an interesting illustration of the commercial service of the plant. In some districts in Colombia, tobacco, wrapped in bales covered by one or two layers of raw ox hide, survives the humidity of the climate, the downpours of frequent rains, and the hardships and costs incident to weeks of ox-cart and mule-back transportation en route to railroad or riverboat.

The people of Paraguay, men and women alike, are among the greatest smokers in the world, the rich soil of this subtropical country supplying not only the local demand but providing an export crop of growing significance. From Argentina to Central America and Mexico tobacco growing for local use is common.

World trade in tobacco. Approximately one seventh of the world's tobacco crop enters into the channels of international trade. The United States, Turkey, Greece, Southern Rhodesia, and India are the chief exporters. American exports average about 460 million

pounds a year. The United Kingdom, Germany, United States, and France lead all nations in imports, British imports amounting to about 300 million pounds annually. The United States imports much tobacco from Turkey and Greece to be blended with domestic tobaccos in the manufacture of cigarettes, but our exports are more than four times larger than our imports.

Tobacco monopolies. Of all the well-known agricultural products tobacco has probably been the most subject to government regulation and control. Tobacco and alcoholic beverages seem capable of bearing great burdens of taxation. To aid this revenue collection Great Britain has long prohibited its growth.

Four general methods are used in collecting such revenue: government tobacco monopolies, internal-revenue taxation, import duties, and export taxation. Latin American countries have resorted to all these methods. For example, Peru maintains a government tobacco monopoly; the states of Brazil have imposed export taxes on tobacco; and Argentina collects considerable revenue from the import duties on tobacco and tobacco products. Venezuela and Guatemala maintain a government monopoly of the importation and printing of cigarette paper, which is sold to cigarette manufacturers, and thus collect a tax for revenue. The United States imposes duties on imports of raw and manufactured tobacco, and internal-revenue taxes on manufactured tobacco of all kinds; imported manufactured tobacco pays both the duties and the internal-revenue taxes.

The duties on tobacco in most countries are so high as practically to preclude the entry of competitive tobaccos. In general, only those types of tobacco which are not produced in a specific country are imported. High duties can be paid on such tobaccos, provided they are essential in the manufacture of certain tobacco products required by consumers.[17]

Tobacco manufacturing. Plug tobacco cigarettes and smoking tobaccos tend to be prepared by the use of much machinery in large factories near the centers of production Winston-Salem and Durham, N. C., Richmond, Va., and Louisville, Ky., are leading cigarette-manufacturing centers, while Philadelphia ranks first in the manufacture of cigars. At one time cigars were made by hand requiring much skilled labor. The trained cigar maker uses little besides nimble fingers and a sharp knife, rolling and shaping the filler, binder, and wrapper into a fragrant Havana cigar. Today most American cigars are made by machine.

Tobacco manufacturing in the United States is dominated by a few big corporations. In 1953 nearly 431 billion cigarettes were manufactured in this country. Six firms accounted for nearly 98% of the total output, namely American Tobacco, R. J. Reynolds, Liggett & Myers, Philip Morris, Brown & Williamson and P. Lorillard. Indeed, the Big Three—American Tobacco, Reynolds, and Liggett & Myers—produced 75% of the nation's cigarettes.[18] Price wars among the giants are unheard of. Every smoker knows that the prices of the popular brands of cigarettes go up or down simultaneously—usually up.

---

[17] U. S. Tariff Commission, *Foreign Trade of Latin America,* Part III, Report 146, 1942, p. 212.

[18] For details of output by companies and by brands, see Harry M. Wooten, "In 1953 Cigarette Sales 2% under 1952," *Printer's Ink,* January 15 1954, p. 36.

12· The Animal Industries

1. MEAT AND THE MEAT SUPPLY

Necessity or luxury? Meat does two things. It nourishes, and it serves as a stimulant or appetizer. As a food, meat furnishes protein and is a muscle builder. The pleasing flavor of meat saves many a poorly cooked meal from being inedible. Although a little meat will suffice as a food and as an appetizer in a well-balanced meal, many people eat more than they need. Much of the world's meat is eaten as a matter of habit.

Poverty and religious taboo are potent forces restricting the use of meat. Hundreds of millions of people seldom eat meat simply because they cannot afford it. These people obtain their protein cheaply from peas, beans, nuts, fish, cheese, and other foods (see Table 12:1). Some 360 million Hindus never eat flesh of any kind because their religion forbids it. Meat is certainly not a necessity.

The demand for meat grows with increasing wealth and income. The peoples of southern and eastern Europe consume more meat per capita than do those in the poverty-stricken Orient (see Table 12:2). The Scandinavians, British, French, Belgians, Swiss, Germans, and Dutch eat more meat than their poorer brethren in southern and eastern Europe. Americans and Canadians consume more meat per capita than western Europeans. Meat today is a luxury possessed chiefly by people with superior purchasing power.

The largest consumption of meat per capita is found in the midst of great surplus-producing areas, where meat is cheapest. Uruguay, Argentina, New Zealand, and Australia now lead the world in per-capita consumption of meat. Each has a large surplus for export, and each has superior purchasing power. Tiny Denmark consumes more meat per capita than any nation in Europe, and it ranks second only to New Zealand in net exports (see Tables 12:2 and 12:3).

In the closing decades of the nineteenth century the Western world enjoyed the cheapest meat supply that it is ever likely to have. This era witnessed the expansion of cheap and rapid transportation, the advent of refrigerated cars and ships, and a phenomenal development of meat-animal production. Today large tracts of good free land are no longer available for grazing. Population is increasing faster than the number of meat animals. High-priced meat is apparently here to stay.

In spite of its huge production, the United States is now a net importer of meat. In 1953 the American people consumed 149 pounds of meat per capita, or about half as much as they did a century ago. Perhaps our ax-swinging ancestors needed more meat than the button pushers of our modern Machine Age.

Meat, animals, men, and land. Man always has the choice of eating plant products directly or, if land is cheap and plant products abundant, he can feed them to animals and then eat the animals. The latter is much the more expensive form, for the making of a

TABLE 12:1. Proximate Composition of Important American Food Materials

Food	Basis	Constituents of the edible portion									Acid %	Fuel value per lb. calories
		Refuse %	Water %	Protein %	Fat %	Ash %	Carbohydrates					
							Total %	Fiber %	Sugar %	Starch %		
Almonds: Dried	E.P.[a]	..	4.7	18.6	54.1	3.0	19.6	2.7	4.4	....	....	2,900
Apples: Fresh, all	A.P.[b]	12	74.0	.3	.4	.3	13.0	.9	....	....	....	260
Bananas, Fresh	A.P.	33	50.1	.8	.1	.6	15.4	.4	....	....	....	300
Beans: Dry seeds, all	E.P.	..	10.5	22.0	1.5	3.9	62.1	3.9	3.6	35.8	....	1,585
Breads, White, commercial	E.P.	..	35.9	8.5	2.0	1.3	52.3	.3	....	....	....	1,185
Butter	E.P.	..	15.5	.6	81.0	2.5	.4	....	....	....	....	3,325
Cabbage: Fresh	A.P.	27	67.5	1.0	.1	.5	3.9	.7	....	....	....	90
Cheese: Cheddar	E.P.	..	39.0	23.9	32.3	3.1	1.7	....	....	....	....	1,785
Chocolate: Unsweetened	E.P.	..	2.3	(5.5)	52.9	3.2	(18.0)	2.6	....	....	....	2,585
Dates: Fresh & Dried	A.P.	13	17.0	1.9	.5	1.6	65.6	2.1	....	....	....	1,245
Eggs: Hen	A.P.	11	65.9	11.4	10.2	.9	.6	....	....	....	....	635
Figs: Dried	E.P.	..	24.0	4.0	1.2	2.4	68.4	5.8	55.0	....	.6	1,365
Fish: Raw, Class 1	E.P.	..	77.2	19.0	2.5	1.3	0	....	....	....	....	445
Grapes, Fresh, American type	E.P.	..	81.9	1.4	1.4	.45	14.9	.5	11.5	....	1.21	355
Lentils: Dry, whole	E.P.	..	11.2	24.7	1.0	3.2	59.9	3.3	....	....	....	1,575
Meat and Poultry: Cooked	E.P.	..	63.0	30.0	6.0	1.2	0	....	....	....	....	790
Milk: Cow, Fresh, whole	E.P.	..	87.0	3.5	3.9	.7	4.9	....	....	....	....	310
Oatmeal or rolled oats: Dry	E.P.	..	8.3	14.2	7.4	1.9	68.2	1.2	....	....	....	1,795
Oleomargarine	E.P.	..	15.5	.6	81.0	2.5	.4	....	....	....	....	3,325
Orange juice: Fresh	E.P.	..	....	....	....	....	10.1	....	9.0	....	1.16	....
Peanuts: Roasted	E.P.	..	2.6	26.9	44.2	2.7	23.6	2.4	....	....	....	2,720
Peas: Fresh, shelled, all shelled, all	E.P.	..	74.3	6.7	.4	.92	17.7	2.2	3.2	8.2	....	460
Peas: Dry, whole	E.P.	..	11.6	23.8	1.4	3.0	60.2	5.4	....	45.1	....	1,580
Pork, cured: Raw, Ham, medium	A.P.	13	37.0	14.7	30.0	4.7	(.3)	....	....	....	....	1,510
Potatoes, Fresh	E.P.	..	77.8	2.0	.1	.99	19.1	0.4	.9	14.7	....	385
Rice: Brown, uncooked	E.P.	..	12.0	7.5	1.7	1.1	77.7	0.6	....	....	....	1,615
Sausage: Frankfurt, all meat	E.P.	..	61.1	14.1	20.8	2.8	0	....	....	....	....	1,100
Soybeans: Dry seeds	E.P.	..	7.5	34.9	18.1	4.7	(12.0)	5.0	8.4	2.1	....	1,590
Sugars: Granulated	E.P.	..	.5	....	....	....	99.5	....	99.5	....	....	1,805
Sweet Potatoes, Fresh	E.P.	..	68.5	1.8	.7	1.07	27.9	1.0	5.4	20.2	....	565
Walnuts: Black	E.P.	..	2.7	18.3	58.2	2.1	18.7	1.9	....	....	....	3,045
Wheat flours: straight, all types	E.P.	..	12.0	11.2	1.1	.5	75.2	.4	....	....	....	1,615

[a]E.P. Edible portion.
[b]A.P. As purchased.
Source: Selected from USDA Circular No. 549, by Charlotte Chatfield and Georgian Adams.

This table is the basis for a rewarding study, if you are interested in your own nutrition or that of the different nations. Read down the columns Protein, Fat, Total carbohydrates, and Calories. Read left to right the lines for the grand champions, peanuts, soy beans, dry beans, walnuts.

TABLE 12:2. The Meat Supply of Selected Countries, 1952

Country	Per-capita consumption (pounds)	Production (millions of pounds)	Net exports (+) or imports (−) (millions of pounds)
United States	144	23,035	373−
Canada	123	1,977	58+
Cuba	79	410	42−
Mexico	39	1,155	114+
Denmark	108	1,193	723+
France	105	4,450	9−
Sweden	100	702	5−
U. K.	96	2,880	2,401−
Switzerland	91	424	19−
W. Germany[a]	89	4,450	71−
Netherlands	78	1,042	123+
Portugal	40	345	1+
Italy	34	1,485	87−
Greece	23	180	5−
Uruguay	243	823	176+
Argentina	230	4,800	640+
Chile	64	381	1+
Brazil	57	3,150	11+
U. of S. Africa	74	935	17−
New Zealand	220	1,296	743+
Australia	208	2,309	511+
India[b]	5	1,645	0
Japan	4	369	0

[a] Averages for 1948–50.
[b] Data for year 1950–51.
Source: Data for India based upon gross supply, adapted from U. N., *Statistical Yearbook, 1952,* New York, 1952, p. 259. Japanese data based upon commercial production, U. S. Dept. of Agr., letter of January 18, 1954. All other data from USDA, Foreign Agricultural Service, *Foreign Agriculture Circular,* August 31, 1953.

pound of meat requires the grass from much land or 5 to 10 pounds of grain, the equivalent of 8 to 15 one-pound loaves of bread. In densely populated, poverty-stricken regions, where there is not enough food for both man and beast, man eats the food and does without the beasts (see Table 12:3).

Japan is an extreme example of a crowded nation with many people, few animals, and little land. Only 16½% of the land area of this mountainous country is crop land, and only 1½% is permanent pasture. In 1951 Japan had a population of 84½ millions, or 571 persons per square mile. It had 2,500,000 cattle, 800,000 hogs, and 500,000 sheep. The ratio of meat animals to men was 1 to 22.

In contrast with Japan, little Uruguay is a flat or gently undulating country with a population of less than 2½ millions, or 33 persons per square mile. Pasture accounts for nearly 70% of the land area, crop land only 7%. Uruguay has long been a specialist in sheep production. In 1951 it had 23,500,000 sheep, 8,200,000 cattle, and 200,000 hogs. The ratio of meat animals to men was 13 to 1.

The meat hero of the Corn Belt. *U. S. Department of Agriculture*

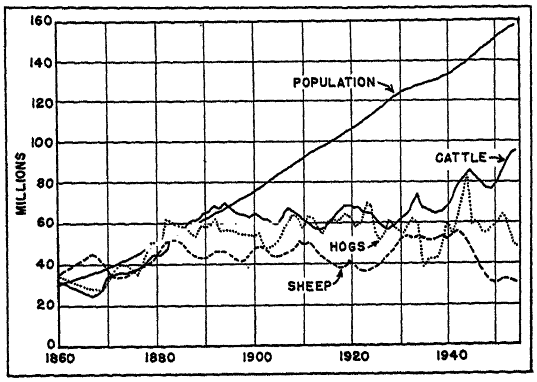
The United States occupies a position betwixt that of Uruguay and Japan. In 1951 we

TABLE 12:3. Average Food Availabilities per Head per Day
(grams)

	France	Germany	China	India
Cereals for food	331.4	309.7	470.1	391.2
Potatoes and other tubers	424.9	482.2	82.5	21.1
Sugar	65.5	65.7	3.3	38.6
Pulse and nuts	32.0	8.5	69.3	60.3
Vegetables	392.9	137.0	154.8	68.5
Fruits	69.9	98.4		71.8
Meat	142.2	139.3	35.2	8.3
Eggs	24.7	19.7	4.1	1.1
Fish	21.9	32.9	7.7	4.4
Milk and cheese	245.0	386.6	—	177.2
Oils and fats	42.0	69.4	17.2	6.8
Included in total:				
Calories (number)	2884	2961	2226	1968
Animal protein	36.6	39.5	5.7	8.3
Vegetable protein	51.4	43.5	65.1	47.8

Source: Journal of Economic and Social Geography, Amsterdam, The Netherlands, February 1954, p. 39.

This table presents facts that are startlingly different. This chapter and the next will give many explanations.



The decade 1890-1900 marks a great change. The new land was all taken. Soon there must be more crops or less meat per person in America.

had a population of about 153 millions, or 51 persons per square mile. Pasture accounted for 35% of our land area; crop land, 24%. We had 82,000,000 cattle, 62,900,000 hogs and 30,600,000 sheep. The ratio of meat animals to men was approximately 1 to 1.[1]

As population increases over a long period of time, the ratio of meat animals to men inevitably declines (see Table 12:4). Intensify agriculture as we may, dense populations find meat scarcer than do sparse populations.

TABLE 12:4. Number of Meat Animals per 1000 Population in United States

	1903	1913	1923	1933	1943	1953
Sheep	841	558	361	422	412	198
Hogs	617	665	618	495	551	342
Beef cattle ..	587	391	397	266	306	356

Source: USDA.

2. SHEEP AND OTHER WOOL BEARERS

Characteristics of sheep. It is generally believed that sheep were indigenous to the mountain lands of Central Asia, and wild sheep inhabit many of the world's mountain ranges today. Perhaps because of mountain ancestry, the sheep is a good climber, a surefooted animal that is well adapted to rugged land. Every summer, flocks of sheep are driven to lofty pastures in the Rockies, Andes, Alps, Pyrenees, and other mountain areas, returning late in autumn to the valleys and plains.

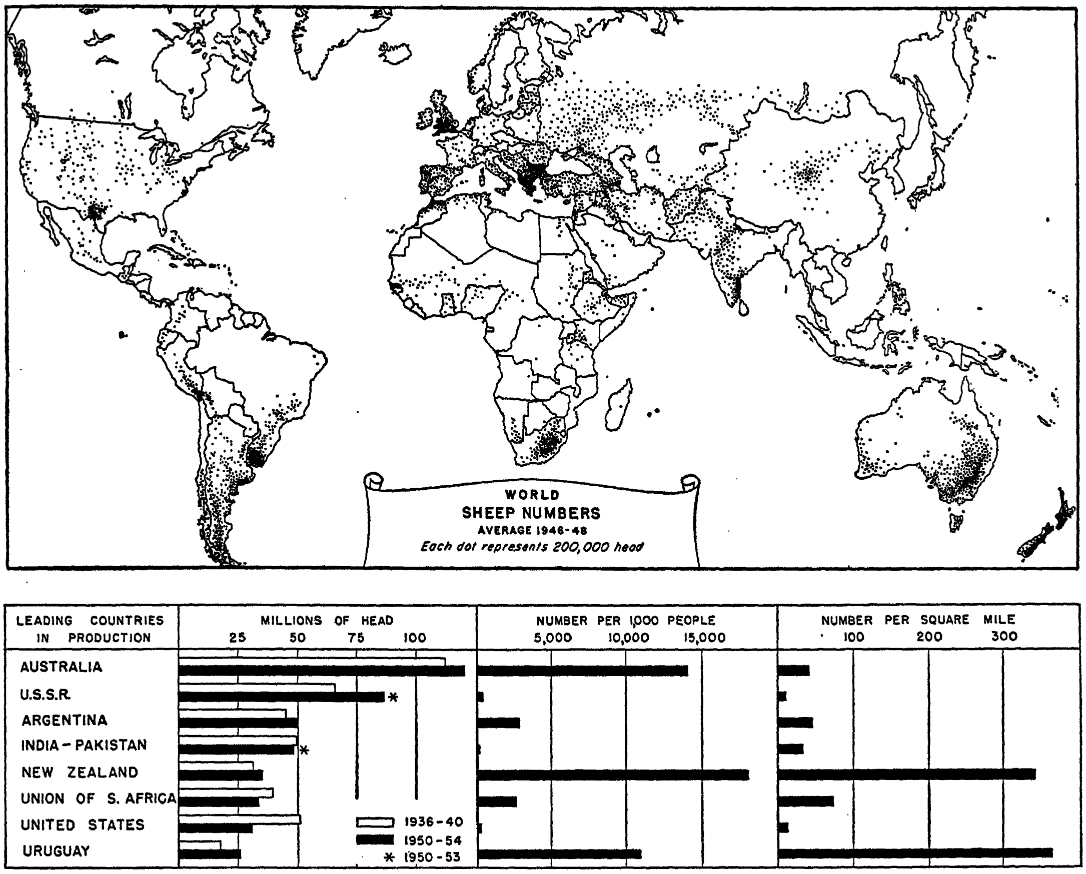
By eating dewy grass at early morn, the sheep can get along with little water. His sharp nose enables him to reach into crannies of rocks for scanty herbage. His cleft lip allows him to nibble grass so close that it may not reseed itself. Indeed, the sheep rivals the goat in its ability to subsist on sparse and scrubby vegetation. Hence, sheep are found in large numbers on semiarid grasslands, as in Australia, South Africa, Argentina, the Soviet Union, and the United States (see

TABLE 12:5. Millions of Sheep in Selected Countries

Country	1911	1936–40 average	1953
Semiarid countries:			
Australia	92.4	112.6	119.0
U. of S. Africa	30.7	39.9	32.0[a]
Spain	15.1	20.0	27.0
Turkey	51.9	21.7	26.5
Italy	11.2	9.7	10.0
Greece	4.6	8.3	7.9
Chile	3.6	5.9	6.3[b]
Algeria	9.0	6.2	6.0[b]
Mexico	3.4	4.8	4.8
Countries partly semiarid:			
U. S. S. R.	38.0	66.0	90.0
Argentina	67.2	44.9	51.0
United States	52.8	51.4	31.6
Countries with sparse population, good rainfall, and remote from markets:			
Uruguay	26.3	17.9	28.5
New Zealand	24.0	31.4	35.6
Countries with dense population and good rainfall:			
U. K.	30.5	26.1	21.7[b]
France	17.1	9.6	7.7
Germany	7.7	4.5	1.5[c]
Switzerland	.2	.2	.2[b]
Belgium	.2	.2	.1
Denmark	.7	.2	.1
World total	615.2	746.8	816.7

[a] Data as of 1951.
[b] Data as of 1952.
[c] Data for West Germany.
Source: USDA, *Agricultural Statistics* (annual).

[1] These ratios for the United States, Uruguay, and Japan are based upon the total number of sheep, hogs, and all kinds of cattle but exclude horses, goats, and other animals that are sometimes slaughtered for meat. Crop land includes land planted in crops (double-cropped area counted only once), land temporarily fallow, temporary meadows for mowing or pasture, and land in orchards, vineyards, and gardens.



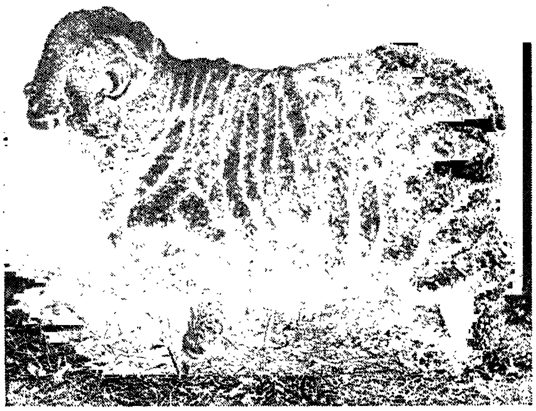
Why such difference in rank? ***U. S. Department of Agriculture***

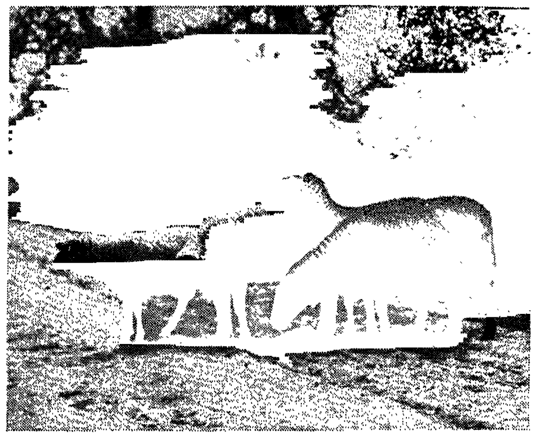
Table 12:5 and colored map at front). Semiarid regions are seldom in crops, and sheep have little competition for use of the land.

The sheep with his warm coat is well equipped for cold climates and thrives in such bleak lands as Patagonia and the Falkland Islands. In tropic heat the fleece degenerates and may disappear, leaving only a coat of hair. The sheep is at its best in temperate lands where abundant rainfall provides rich, succulent grass throughout most of the year. With good dependable pasturage, a little land may support many sheep, as in Great Britain, New Zealand, and Uruguay.

Sheep production involves little labor and is well adapted to sparsely populated regions. One man on horseback with a few sheep dogs can take care of 3000 sheep. In many areas the shearing of wool is done with mechanical shears. Although labor requirements are small, sheep require constant care. Sheep are weak, defenseless, stupid, subject to disease, and are easy prey to accident, dogs, and thieves. The stupidity of sheep long ago gave rise to the derisive epithet, "Muttonhead!"

Sheep and the cold margins. The Falkland Islands in the South Atlantic afford a good illustration of the service of sheep to the people of a bleak, remote, and sparsely populated land. The main islands, East Falkland and West Falkland, have only 2280 inhabitants and are smaller than Connecticut. January, the warmest month, has an average temperature of 49°F.; July, the coldest month, 37°F. Cold rains or light snow occur on 243 days of the year, and fog occurs on one day in six. The westerly winds blow so hard that trees cannot grow. Barley and oats rarely mature, hardy vegetables can be produced only with difficulty, and less than 150 acres





(Left) Wool sheep. Merino breed. A rack of bones with enough skin to cover a small cow. Dry pastures, Australia. Breeders have produced a strain with few wrinkles and fewer pounds of wool. *U. S. Department of Agriculture. (Right)* A mutton breed: lush pastures, West Europe, New Zealand. *J. Russell Smith, taken in England*

are under cultivation. There are few horses and cattle. Over 600,000 sheep graze upon 2,876,000 acres of windswept moorland, and more than 4 million pounds of wool are exported annually. Fuel, food, clothing, and supplies are imported.[2]

In similar latitudes the peoples of bleak Patagonia, Tierra del Fuego, the Faroe Islands, and Iceland are dependent upon the export of sheep products. Here, as in semiarid and rugged lands, sheep encounter virtually no competition for use of the land.

Wool sheep and mutton sheep. For centuries sheep have been prized for their wool, meat, skins, and tallow, and in some places ewe's milk is used in the manufacture of cheese. Nobody knows when man first used sheepskin coats and caps as protection against the cold of winter. History contains no record of the first use of wool in making cloth, so remote was its beginning.

Some breeds of sheep have been developed primarily for their wool, others for their mutton, and many dual-purpose sheep have been developed through crossbreeding. The little Merino is the champion wool bearer (see Fig. 212). In the fourteenth century it was introduced from North Africa into the dry plateaus of Spain, a region famous for its sheep since the times of Hannibal and Caesar. By careful breeding and selection the Merino has been developed into a little bony animal with a wrinkly skin, thereby furnishing for a minimum of feed a little frame with a maximum of surface covered with a marvelous fleece. At times the fleece, together with the grease, amounts to 36% of the weight of the entire animal, and it may have 60,000 fibers per square inch of skin. With its unusually fine, strong, and curly fiber, the Merino's dense soft fleece, is unrivaled.

Many important breeds of sheep have originated in Great Britain, chiefly England, as their names testify. Among them are the Cheviot, Cotswold, Dorset Horn, Hampshire Down, Leicester, Lincoln, Oxford Down, Romney Marsh, Southdown, Shropshire, Suffolk, and Sussex Down. Most English sheep are coarse-wooled and of the mutton-producing type, the lowland breeds being heavier than those of the highlands.

In contrast with wool, mutton and lamb are perishable commodities. Prior to the development of modern transportation and re-

[2] The port of Stanley (pop. 1270) has one school with 200 pupils. The sparse rural population is served by 4 schools and 8 traveling teachers. On December 31, 1951, deposits in the savings bank at Stanley amounted to £782,910. Most Falkland Islanders are of Scottish descent.

times last for long periods, cutting off both grass and water, so that the sheep starve by millions, as in the period 1894 to 1898 when continued drought reduced the sheep flocks from 110 million to 84 million.

More than one third of Australia receives less than 10 inches of rainfall a year; two thirds gets less than 20 inches; while one half the country has practically no rain during six months of the year. Rainfall is unreliable in fully three fourths of the country. A given locality in four years may have an average annual rainfall of 15 inches, consisting of 22, 18, 12, and 8 inches. In some arid areas huge excavations, or tanks, are used to collect surface waters after the infrequent rains, and artesian wells are used wherever possible. In different localities along the 10-inch annual-rainfall line (front endpaper), the number of sheep per square mile varies from 0 to 70. In contrast, the humid highlands of the southeast support 200 to 600 sheep per square mile.[3]

New South Wales possesses nearly half the sheep of Australia (see Table 12:5). Queensland, farther north (half within the tropics) with more rain and heat and better forage, is therefore the leading cattle state, since cattle stand heat and moisture better than sheep and require better pasture. The great bulk of Australian exports of frozen mutton, lamb, beef, and veal are destined for Great Britain, which regularly imports more meat than all other nations combined. Although wool exports are more widely distributed, most of them are destined for Britain.

New Zealand. New Zealand, further south than Australia, with the good rainfall of the prevailing westerlies, is an excellent sheep country. Mild temperatures in the 50's and 60's permit year-round grazing. About 47% of the nation's land area is devoted to pasture, sheep production and dairying being the leading industries. Most sheep are raised on farms less than 500 acres in size.

Most of the sheep on North Island are raised in the eastern and southern sections, while virtually none is raised on the interior plateau, where volcanic peaks and pumice-covered plains are almost barren. On South Island production is concentrated chiefly in the eastern and southern lowlands and along the eastern slopes of the Southern Alps. Luxuriant pasture on the rain-drenched western slopes of the mountains can support 5 sheep per acre throughout the year.

With a population of only 2 millions, New Zealand has large surpluses of meat and wool for export. New Zealand now accounts for more than one half of the world's export of mutton and lamb, and it ranks second to Australia in the export of wool. In 1952 New Zealand produced 648 pounds of meat per capita, or about twice the per-capita output of its chief rivals—Uruguay, Argentina, and Australia.

Argentina and Uruguay. These River Plate countries, as the English often call them, are important in the world of sheep. Rainfall in Argentina decreases with increasing distance from the Atlantic until the desert lands east of the Andes are reached (see front endpaper and folded, colored map). At one time the grassy plains, or pampas, were devoted entirely to the production of horses, cattle, and sheep. In pioneer days sheep were so cheap that large numbers were slaughtered and the wool pulled from their bodies, this process being more expeditious than shearing. (The carcasses were thrown away or used as fuel.) Not until 1903 did the exports of wheat, corn, flaxseed, and other farm products surpass in value the exports of the long established grazing industry.

Today the humid portions of the Argentine pampa are devoted chiefly to grain and alfalfa, beef cattle occupying most of the pasture land. Most of the nation's sheep are in the southern two thirds of Buenos Aires province, where cool, moist summers and much poorly drained land are not good for alfalfa and grain. This is a land of mutton sheep and crossbreds, the

[3] See Griffith Taylor, *Australia*, E. P. Dutton & Co., New York, 1940, pp. 62–70, 306–314, and "Agricultural Regions of Australia," *Economic Geography*, July 1930, pp. 234–237.

woolly Merino having been exiled to the semiarid margin of the pampa.

A secondary concentration of sheep occurs in the extreme southern portion of the Patagonian plateau and the adjacent island of Tierra del Fuego, owned by Argentina and Chile. In this bleak land sheep subsist on tussock grass and shrubs. Ranches are large, and one sheep-shearing shed at Maria Behety in Argentine Tierra del Fuego handles 6000 sheep a day. Argentina now has about 50 million sheep, as compared with a peak of 74 millions in 1897.

Uruguay, across the Paraná River from the best part of Argentina, is from end to end an undulating grassy plain. Ten times as much land is devoted to pasture as to grain and other crops; sheep outnumber cattle more than 3 to 1; and pastoral products account for about 80% of Uruguayan exports. Uruguay is likely to remain a pastoral country for many years.

South Africa. Like Australia, the Union of South Africa has mountains near the ocean that shut off the southeast trade winds from the interior, leaving a moist plain near the sea for agriculture and cattle raising. Back of the mountains is a wide expanse of interior, generally suitable for sheep, which have remained fairly constant in number since 1910. Sheep are widely distributed in the southern two thirds of the Union, maximum density occurring in dry and hilly lands between the Kalahari Desert and the crop lands of the southeast coast. The Union of South Africa has long been a major exporter of wool.

Western United States. The plains of the United States have not been at any time so exclusively devoted to sheep raising as have similar parts of Australia and Argentina, because the vigorous and hostile Indians held the American plains against the advance of the white man until the railroads came. Then cattle could be sent to market, and the sheep-growing and wool-exporting stage so common in the Southern Hemisphere was less necessary. The first industry of our West was the rounding up of cattle on the plains by the cowboy. Sheep herding came later, and rivalry between cattle and sheep owners for the use of the unfenced public domain resulted in many minor "wars," with accompanying bloodshed.

Today grazing is the dominant use of the land west of the 20-inch annual rainfall line until the Pacific slope is reached (see front endpaper and colored map). Sheep often succeed where other forms of land use are unprofitable or impossible, and the present distribution of sheep clearly reveals their adaptability to rugged, dry, and sparsely populated land. In 1953 about 82% of the nation's sheep were on farms and ranches west of the Mississippi River; 34% were in the Rocky Mountain states; and 18% were in Texas, which far surpasses other states in sheep production.[4]

Migratory grazing is common in the West, and many of the sheep herders are Mexicans. The sheep herder moves with his flocks from pasture to pasture during the summer season, returning in autumn to the home ranch. Shearing occurs in the spring. Some crews of shearers begin work in February or March in the Edwards Plateau of Texas and move northward with the wool-clip season, concluding operations in southern Canada in May or June. Prior to slaughter, many sheep are fattened on the irrigated farms of the west. Denver, Colo., and Ogden, Utah, lead all other meat-packing centers in the slaughter of sheep.

Eastern United States. Sheep production in the East stands in contrast with that of the West. English mutton breeds predominate on eastern farms, whereas the Merino, Rambouillet, and other wool breeds are common in the West. Eastern flocks are small, usually less than 50 sheep each; they are kept in fenced pastures; and they receive personal care from their owners. Ohio is the only state east of the Mississippi possessing as many as 1 million sheep, and there is no large agglomeration of sheep comparable to that of central and west-

[4] Millions of sheep in leading states, 1950–53 average: Texas, 6.6; Wyoming, 2.1; California, 2.0; Colorado, 1.8; Montana, 1.7; Utah, 1.4; New Mexico, 1.4; Iowa, 1.4; Ohio, 1.2; Idaho, 1.2; Missouri, 1.1; South Dakota, 1.0.

ern Texas. On eastern farms sheep raising is usually a sideline rather than a major enterprise. In populous sections, where land values are high and agriculture is intensive, sheep are unable to compete for use of the land.

The principal concentration of sheep in the East occurs on the hilly land of the Ohio valley. In contrast with other eastern sheep-growing areas, where emphasis is strongly on meat production, a million Delaine fine-wool Merinos graze on the hills of southern Ohio and Kentucky.[5] In the Corn Belt it is common practice in the autumn for farmers to buy carloads of lean lambs from the western range and fatten them on corn and hay for the winter market. Many of the eastern sheep owners make a specialty of rearing their lambs in the winter season and sending them to market early in the year when they command a very high price—"hothouse lambs."

The United States is surpassed in the production of sheep by Australia, the Soviet Union, Argentina, India, and New Zealand. On January 1, 1954, there were nearly 31 million sheep and lambs on American ranches and farms. This country now imports about 70% of its wool supply, as compared with 20% in prewar years. The American people consume about 4 pounds of lamb and mutton annually, as compared with 72 pounds of pork and 68 pounds of beef and veal. Our imports of lamb and mutton are small but increasing.

Western Europe. The great increase of sheep in the Southern Hemisphere has helped local causes to produce a decline of sheepkeeping in most parts of Europe. Throughout western Europe the sheep industry resembles that of eastern United States, and lamb and mutton are of more value than wool. The field in grain will produce more food than in sheep pasture, so that the grain field, the garden, the dairy farm, and the sugar-beet field have often taken the place of the sheep—and the valuable wool can be imported more easily than the bulkier food products. Some fine mutton sheep, however, continue to be kept in the most intensely cultivated parts of Europe, as in Belgium, the Netherlands, France, and Germany, but they are usually in the poorer, rougher, more scantily populated parts of these countries. Some of the European sheep are fed on barley and rape, a succulent cabbagelike plant that grows in sandy soil.

Great Britain had an early start in sheep raising, and for centuries the Lord Chancellor in the House of Lords has sat upon a woolsack, symbol of the commercial importance of wool. The British people prize mutton and especially British mutton; their moist climate gives abundant grass; their low tariff policy makes easy the importation of grain, which is cultivated much less than on the nearby continent, and in its place are sheep and cattle pastures.

Upland sheep are of great importance in the highlands of southern Scotland and northern England, the Pennine Range, the highlands of Wales, and the moorlands of the Cornish peninsula. Some of the most famous sheep "walks" are located on the well-drained limestone and chalk hills of southern England. Sheep remain important on the eastern lowlands, a major concentration occurring in Kent in the extreme southeast. Although sheep production is gradually declining, Great Britain has 223 sheep per square mile, as compared with 360 in Uruguay and 348 in New Zealand.

The Soviet Union, the Mediterranean basin, and Asiatic lands. The Soviet Union ranks second to Australia in sheep production and has not regained the position of world leadership that it held briefly in the late 1920's.[6] In 1952 the Soviet Union had about 465 sheep per 1000 people, as compared with 13,560 in Australia and 205 in the United States. It continues to import wool. Among its principal sheep-producing areas are the slopes of the Caucasus, the Volga plains, the Crimea, and Soviet Central Asia, especially Kazakhstan. Widespread droughts, such as

[5] "The Woolgrowing Industry in the United States of America," *World Wool Digest,* March 3, 1954, p. 60.

[6] Average number of sheep in the Soviet Union, in millions: 1926–30, 123; 1931–35, 53; 1936–40, 66; 1946–50, 68; 1950–53, 87 (see Table 12:6).

occurred in 1921–22, 1932–33, and 1938, are the chief handicap to Soviet sheep production.

The Mediterranean climate, with its winter rain and dry summer, is very wholesome for sheep, especially if they can have mountain pastures. In this belt are Spain with 26 million sheep and French North Africa with 20 million. Sheep are very important in Greece, Albania, Yugoslavia, and Bulgaria—mountainous, isolated, primitive.

Sheep are very common and very important in the semiarid Near East, in Iran, Afghanistan, the mountainous parts of India, Tibet, Manchuria, and the interior dependencies of China. India and China lead the Far East with 42 and 21 millions of sheep respectively. From all these countries there is an export to the Western world of the coarse wool yielded by the hardy native sheep belonging to those careless Asiatic peoples who have seldom possessed themselves of the better breeds of western Europe. Throughout this whole region from the Bosporus to the Amur Valley the sheep live almost entirely by pasture, which is subject to the cruel uncertainties of climate —and despite the shifting of flocks from place to place, as described in the book of Genesis, disasters occasionally occur.

Latin America and Africa. There is some sheep husbandry for local use throughout the mountainous regions of Mexico, Central America, and the Andean regions of South America. Peru, with 18 million sheep, leads these highland countries in sheep production, while Mexico, with 6 millions, rivals our state of Texas. In Eucador, Peru, and Bolivia the Andean plateaus spread out in greater expanse and, with their rough surface and cool and semiarid climate, are a good place for sheep. There is an export of wool. It is true these countries are in the tropics, but the natives of the Bolivian Plateau wear woolen masks to protect their faces from the biting blasts of the winds that sweep across the landscape 2½ to 3 miles above sea level. (Note Fig. 17.)

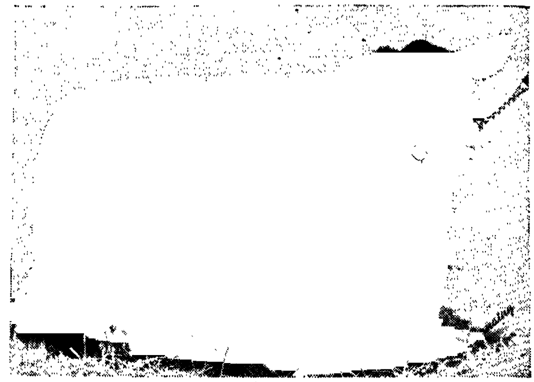
The lofty plateaus and mountain slopes of Peru and Bolivia are the natural home of the llama, alpaca, and vicuña, which are famous for their very fine, long, and soft wool. The llama and alpaca were domesticated centuries ago, and the llama has long served as a beast of burden. About 5 million llamas and alpacas graze on the sparse vegetation of the Peruvian and Bolivian highlands. The wild vicuña is found only at elevations above 13,000 feet and, because of its valuable wool, is threatened with extinction by hunters.

In tropic Africa the highlands of Kenya and adjoining Uganda support about 5 million sheep. It is possible that sheep production may increase in African highlands in the future.

The goat. The goat's much jested ability to eat anything indicates that it is one of the hardiest of animals, capable of living under the most severe dietary conditions. Accordingly, where land is good and pastures are fat, goats are few; but where sheep can scarce subsist, the goat thrives on the browse of desert and mountain shrubbery. The goat fights enemies that would kill a sheep or else scrambles to an inaccessible rocky pinnacle for safety. The sheep has greater resistance to extreme cold, but the sturdy and frugal goat is better adapted to aridity, rugged terrain, and tropic heat; and it thrives in the midst of human poverty.

On the Indian subcontinent (India and Pakistan) approximately 62 million goats are scavengers in a crowded and poverty-stricken land, the chief concentration of goats occurring in the Ganges Valley. In Turkey, French North Africa, Spain, and other Mediterranean countries nearly 50 million goats graze upon dry and frequently rugged land. Between the Indian subcontinent and the Mediterranean some 18 million goats are raised in arid Iraq, Iran, and Afghanistan. The Soviet Union and China have about 20 million goats apiece. In the Western Hemisphere goats are of lesser importance, Brazil, Mexico, and Argentina being the leading producers.[7]

[7] Millions of goats in leading countries in 1951, or latest year available: India, 47; U.S.S.R., 21 (est.); China, 18; Turkey, 17; Pakistan, 15; French North Africa, 14; Iran, 9; Brazil, 9.



(Left) **See cactus at right. This cow of beef breed, starving in drought; U. S. Southwest. Given 6 months of full feed, she would resemble the next to substantial extent.** ***U. S. Soil Conservation Service.*** ***(Right)*** **Prize-winning specimen of European beef breed.** ***Pennsylvania Farmer***

Some breeds of goats have been developed primarily for milk, others for their wool or hair, and some for their meat. Dairy goats often provide the only milk supply in arid regions and in densely populated lands. All kinds of goats are prized for their skins, which are used in making leather. Some of the world's finest leather, such as cordovan and morocco, are made of goatskin. More than 30 million goat and kid skins, nearly all of foreign origin, are used by the American leather industry every year.

The Angora goat. Among the goats that are raised for their wool or hair, the Angora is now most famous. The Angora is a native of the Anatolian Plateau of Turkey and has been introduced into South Africa, the United States, and other countries. The hair of the Angora is called mohair and is remarkably long, fine, soft, and silky. It is used in upholstery, lightweight clothing, and other fabrics. Although mohair production in the United States amounts to about 13 million pounds a year, imports are necessary.

Of 2,444,993 goats and kids reported by our 1950 census, about 86% were located in Texas, the Edwards Plateau being the outstanding goat center. The Edwards Plateau is a dry grazing region, where beef cattle, sheep, and Angora goats graze together. The cattle feed chiefly upon the grass, and the sheep and goats subsist on weeds, shrubs, bushes, tree leaves, and even mesquite. Water tanks are indispensable for the cattle.

3. BEEF CATTLE

Distribution of cattle. Although cattle are now widely distributed throughout the world, a dozen countries possess nearly 70% of all cattle. Indeed, more than one half the world's 845 million cattle are located in India, the United States, the Soviet Union, Brazil, and Argentina.

The largest concentrations of cattle occur in four major areas: (1) the Indian subcontinent, where few cattle are used for meat or milk and nearly all serve as draft animals; (2) Europe, with dairy cattle predominant in the west and beef cattle in the east; (3) the United States, with beef cattle predominant west of the Mississippi River and dairy cattle to the east;[8] and (4) the pampas of Argentina and Uruguay and the plateaus of southern Brazil, important producers of beef. Lesser concentrations of beef cattle are found in eastern Australia, South Africa, and the interior plateaus of Mexico (see Fig. 222).

The ability of cattle to withstand heat and moisture enables them to thrive in lower latitudes than sheep. On the other hand, they are not so well adapted to rugged terrain, aridity, and cold.

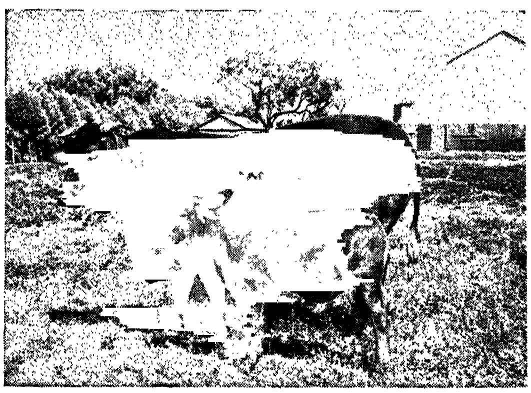
[8] Of 93.7 million cattle and calves on American farms in 1953, about 36.9 millions were "kept for milk" and 56.8 millions were classified as "other cattle." For data regarding the number of cows, heifers, calves, steers, and bulls, see USDA, *Agricultural Statistics, 1953,* Table 443, p. 332.

Pioneer cattle on the great plains. Wherever there are wide spaces of untilled grasslands we are likely to find cattle, especially if the pasture is good rather than poor. They were pioneers during the nineteenth century upon the vast plains that the white man won from the wild animals and natives in North America, South America, Australia, and Central Asia. With their size, strength, and speed, they can combat dangers, or, if necessary, flee from them. They are tough and healthy beasts.

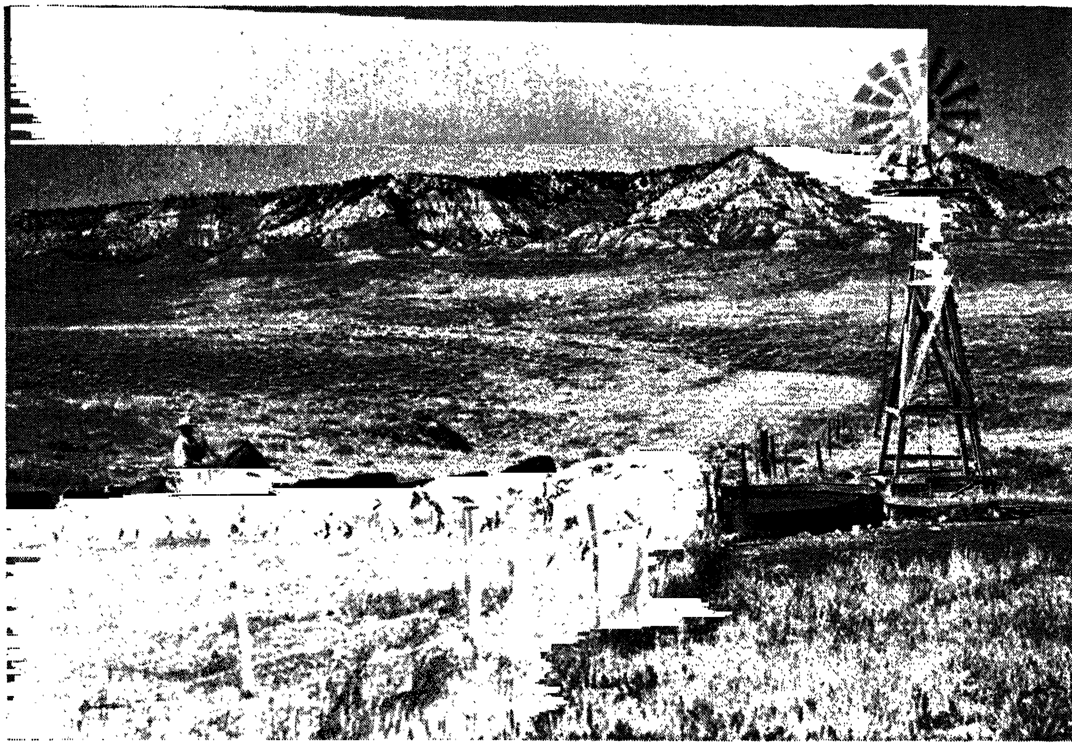
In the first stage of occupation of new plains, before transportation has been well developed, the only export products cattle can furnish are the nonperishable hides and tallow. A century ago the half-breed Indians on the plains of the Argentine were producing these commodities. A little later the American Indians and frontiersmen were skinning buffalo (bison) for their hides upon the great American plains reaching from southern Texas to Lake Winnipeg and beyond. In a remarkably short time the white man's rifle exterminated the buffalo, and his place was promptly taken by the long-horned Texas cattle, which had run wild with him for three centuries since their ancestors had got away from the early Spanish settlers. In living with the buffalo on the plains the cattle had become well adjusted to the conditions of the life. Their long horns were admirable defense against wolves and bears; their long legs and muscular bodies were efficient in flight. But the animal himself was not very good for beef, and so the Longhorn, in turn, gave way to better breeds imported from England, particularly the white-faced Hereford.

The American beef-cattle industry. Ranchmen took possession of the great open plain west of the 100th meridian, where grassland was too dry for good farming. Under the original Homestead Act, the federal government gave each settler 160 acres, an amount that was later increased to 320 and then to 640 acres. Such grants were generally too small to support a ranchman and his family in a land of scanty pasture. Hence, ranchmen branded their cattle, turned them out upon the public domain in great numbers, and then, after an annual round-up (when all the cattle in a large area were brought together), each man took the cattle that had his brand and sold them. This was a very cheap way to raise cattle.

The freedom of the range naturally led to overstocking. The grass, especially in periods of drought, was eaten so close that it could



(Left) Specimen humped cattle, Zebu, Indian breed in Brazil. Stands heat better than European breeds, U. S. experimenters busy now crossing this with European breeds to get new and better breeds. ***American International Assn.*** ***(Right)*** **Cow and calf, Santa Gertrudis, new breed, Zebu and European. Unlike other breeds, hind quarters, which contain the best beef, are heavier than forequarters.** ***Santa Gertrudis International***



Cattle, rancher, water tank, windmill. Anywhere—Mexico City to Alberta, Kansas to California. ***U. S. Department of Agriculture***

not produce seed, and in many places it died out. As a result the plains do not now support so many cattle as they once did and are being greatly injured by both wind and water erosion and by the advance of inedible weeds. A belated Grazing Act now restricts the number of cattle that may be grazed upon the public domain.

During the present century the public domain has steadily shrunk in size. Farmers, stimulated by high prices and gambling on the uncertain rainfall, have invaded the eastern portion of the grassy plains. As a consequence, the total area of grazing land has decreased; many small ranches have failed; and the remaining ranches have become larger and more self-sufficient in pastureland. Most grazing land is fenced with barbed wire. Cattle raising has become more scientific, and many cowboys now ride the range in jeeps.

Ranches in the American West. On the semiarid lands of the American West, every ranch has its windmills, or electric pumps, and water tanks. Most cattle are unsheltered throughout the year, but nearly every ranch produces some hay to provide feed during winter blizzards, when grazing is temporarily impossible. Because of the modern demand for baby beef, few steers spend more than two summers and one winter on the range.

Irrigation in the West is important to the cattle industry. Indeed, beef is the chief commodity produced on most of the irrigated districts of the United States. Alfalfa leads all other irrigated crops in the area under cultivation. This drought-resistant plant sends its roots to great depths in search of moisture. It yields heavy crops of hay, in from one to ten cuttings a year according to climate. Fortunately, the irrigable valleys are widely scattered throughout the cattle range from Canada to Mexico and from western Kansas to Oregon, so that these favorable alfalfa fields are really scattered oases in the scanty and semiarid pastures. During winter and the seasons of drought, alfalfa hay supplies the cattle from

the ranges with abundant feed and fattens them for market (see Fig. 232 left). In the sugar-beet districts, beet pulp is commonly used as feed.

Cattle in the Corn Belt and the South. Each year, following the autumn round-up, many western cattle are shipped to Corn Belt farms, where they are fattened on corn for a few months prior to slaughter in the great meat-packing plants. In recent years the Corn Belt has become a major producer of beef cattle as well as a cattle-fattening region.[9] The rise of the Corn Belt as a cattle-rearing region has been due largely to two causes. (1) The demand for baby beef permits more generations of cattle to be raised and marketed in a shorter time, resulting in a greater cash return from expensive farm land. (2) The replacement of the horse by the tractor has released thousands of acres from growing horse feed, this land now being available for the production of feed crops for cattle or for use as pasture land. It is not surprising that large concentrations of beef cattle occur in the corn-producing states of Iowa and Nebraska and also in Texas, where cottonseed cake is widely used as feed.

In recent years the production of beef cattle has grown rapidly in the South, particularly in Florida, where year-round pasturage prevails. New breeds made by crossing with Brahman cattle, which are able to sweat and thrive in the moist warm climate, are increasing in this section of the country, and the cattle tick has been conquered by the simple expedient of dipping cattle in a disinfecting bath.

In spite of our large-scale production of beef cattle, the United States is now a net importer of beef and veal. Although prices are high, Americans apparently have the purchasing power to eat T-bone steaks.

Beef cattle in Europe. Although dairy cattle outnumber beef cattle in western Europe, beef production is important. In contrast with the cafeteria system in the American West, where a steer may travel miles to get three square meals a day, most cattle in western Europe are fed by the farmers. Except where land is too rough for tillage, European cattle generally live most of the time in barns and have their feed brought to them, because by this means the arable land can be kept in cultivated crops that are more productive than pastures. This carrying of feed to cattle goes far to explain the large number of cattle per square mile in western European countries (see Fig. 222).

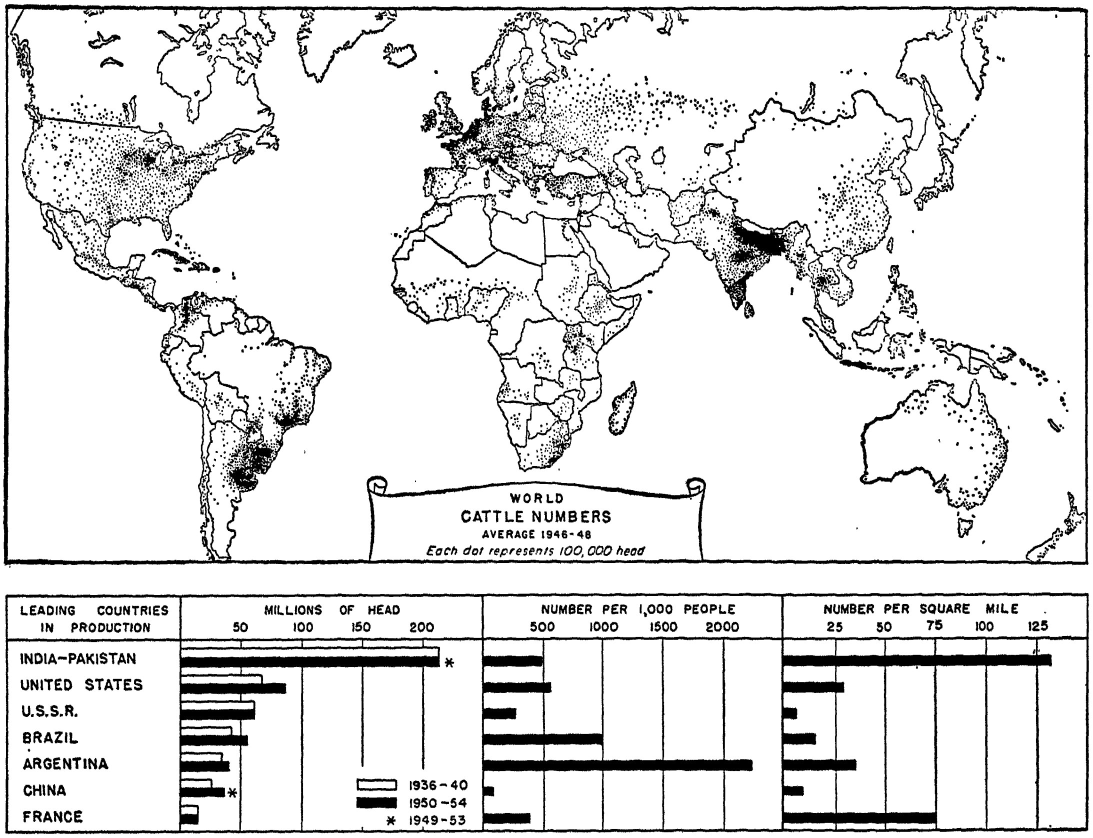
The stall-fed cattle of western Europe consume large quantities of hay, root crops, sugar-beet pulp, and grain. To augment domestic supplies, large imports of feedstuffs are necessary, chiefly grain and cottonseed cake.

In some areas rich pasture lands are available for beef cattle, as in Ireland, the Cornish peninsula of England, and the peninsula of Brittany in France. Where pasture is scarce, economy is the rule. A common practice is to tie cattle to a row of stakes; when the grass is cleaned off around the stakes, the stakes are moved.

Great Britain is especially famous for the quality of its beef cattle, and many a British farmer reaps a considerable income from the export of breeding stock. Among the major breeds are the Hereford, Aberdeen-Angus, Shorthorn, Red Poll, Devon, Sussex, Galloway, and West Highland.

All the nations of western Europe, with the sole exception of Denmark, are importers of beef and veal, most of which now comes from the pastoral countries of the south temperate zone. In prewar years, prior to the Iron Curtain, western Europe was partially supplied with imports from southeastern Europe and the Soviet Union. The plains of Hungary and European Russia have long been important producers of beef cattle. The Soviet Union, however, is not yet a land of plenty, for the

[9] Fully two thirds of all Corn Belt beef cattle are now bred within that region. See Erich W. Zimmermann, *World Resources and Industries,* rev. ed., Harper & Brothers, New York, 1951, p. 304, and George T. Renner, Loyal Durand, Jr., C. Langdon White, and Weldon B. Gibson, *World Economic Geography,* T. Y. Crowell Co., New York, 1951, p. 263.



Compare France with Argentina, with China: a Brazilian person with a Chinese. Note increases in South America. ***U. S. Department of Agriculture***

Russian worker must toil five times as long as does an American to earn a pound of beefsteak.[10]

The dry summers of the Mediterranean climate do not produce good pasture, so that in those countries cattle are not so important as in North Europe. Italy has 8½ million cattle, as compared with 10 millions in Great Britain, but Italian beef production is less than one half that of the British. Throughout the Mediterranean region many cattle are draft animals—slow, powerful, and tough oxen.

France, West Germany, and Great Britain are by far the leading beef producers in western Europe. In 1953 the nations west of the Iron Curtain had about 79 million cattle. Their combined production of beef amounted to more than 4 million tons, or about 80% of production in the United States.

Beef-exporting countries of the south temperate zone. Since the conclusion of World War II, more than three fourths of all beef and veal exports have come from Argentina, Australia, Uruguay, and New Zealand, much of the remainder being shipped from Brazil, Canada, and Mexico. The continued dominance of four countries in the export trade reveals relatively low costs of production, surpluses for export, and economical means of preserving and transporting meat.

Years ago the refrigerator ship, refrigerator car, and the cold-storage plant made possible the carriage of meat to market halfway around the world, so that the ranchers of the south temperate zone no longer keep cattle merely for their hides, tallow, and bones. Every year millions of quarters of beef move into the freezing chambers of the ships that carry them

[10] American Meat Institute, *Food for Thought*, Chicago, February 1954, p. 6.

across the entire torrid zone to deliver them, still frozen, to cold-storage warehouses at Liverpool, London, Glasgow, Lisbon, Barcelona, Genoa, Hamburg, Oslo, and other seaports.

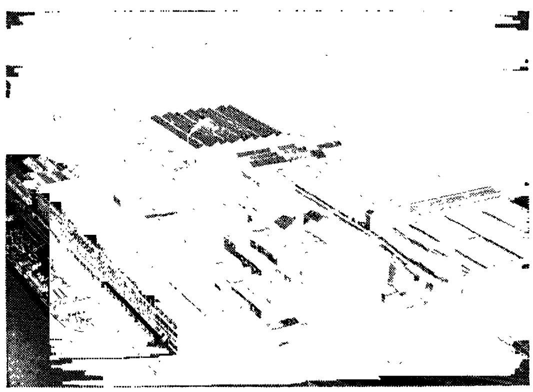
Refrigerated and canned beef now account for the great bulk of all exports, although some beef moves to market in other forms, notably beef extract, pickled beef, jerked or sun-dried beef, and various pastes and meals. The United States has become a major importer of canned beef, but most frozen and chilled beef is destined for Great Britain and other western European nations.

Jerked beef, known as *charque* in Brazil and as *tasajo* in the Rio de la Plata countries, is meat that has been cut up in strips, salted, and cured in the sunshine. It will keep almost indefinitely. Although much jerked beef is produced and consumed in areas where refrigerating facilities are nonexistent, exports are now small. The flavor does not charm.

Beef extract is a convenient means of putting a big roast in a small bottle, the manufacture of it therefore being an industry that could go to the farthest corner of the globe to find cheap beef. Almost every drug store in the world keeps a well-known brand of beef extract that has for some decades been manufactured on the banks of the lower Paraná. Annual exports of beef extract from Argentina and Uruguay amount to about 7 million pounds, worth more than $8½ million.

With limited home markets, Argentina, Australia, Uruguay, and New Zealand normally have large surpluses of beef and veal for export. In each of these countries the ratio of cattle to men is high, Uruguay leading in 1953 with 3330 cattle per 1000 persons. The beef cattle of these countries and of southern Brazil are raised on temperate and humid grasslands not far from the sea, and during the present century the herds have been greatly improved by the importation of prize-winning breeding stock from Great Britain.

The Argentine pampa is truly a kingdom of beef. The best land is devoted to beef cattle, and much of it has been planted in alfalfa,



Meat-packing plant, Argentina. Covered cattle sheds, open pens right. ***Armour & Co.***

which can support at least four times more cattle than the native grasses. Indeed, it is unnecessary to fatten alfalfa-raised cattle on grain prior to slaughter. The *estancias,* or ranches, have been owned by the same wealthy families for generations, and more than 300 of the *estancias* exceed 25,000 acres in size. The cattle are herded by the picturesque *gaucho,* counterpart of the American cowboy. In most years Argentina provides about one half of the world's exports of beef and veal.

Dry South Africa. In contrast with the meat-exporting countries of the south temperate zone, the Union of South Africa seldom has a surplus for export and is usually a net importer of meat. Scanty rainfall in South Africa favors sheep, which outnumber cattle about 3 to 1. Most of the beef cattle in the Union of South Africa are raised not far from the southeastern coast.

Tropic climate and cattle. It has long been known that cattle did not do as well in the tropics as in the temperate latitudes, and scientific research is now giving the reasons.

(1) Common cattle of America and Europe are incapable of sweating, and therefore in hot weather they actually get a fever temperature.

(2) Many species of troublesome insects make discomfort and bring a number of diseases.

(3) Vegetation that grows in such heat as that of Panama and the Congo shows marked deficiency of vitamins when compared to prod-

ucts of similar species grown in the United States.

(4) The heavy rainfall of many tropic localities has so leached the soil that the grass has marked deficiencies of necessary minerals, especially phosphorus. These deficiencies retard development and expose the cattle to disease in many tropical countries and some parts of the southern United States.

(5) The coarse tropical grasses have little protein—the grass of Dakota has more nutriment than that of the Venezuelan llanos or our own Cotton Belt.

The United States government dairy at Colón, with 600 cows supplies the Canal Zone. They produce good strong young stock but say that they *must* feed mineral concentrates especially prepared in the U. S. Also they feed the cattle imported grain. Colón is in the true Tropic Rain Forest zone, and the boa constrictor, covered with ticks, is one of the pests of the dairyman's pastures.

Large tropic areas have very few cattle, notably the rain forests and the deserts (see map inside front cover). In hot and humid equatorial Africa, as in the Belgian Congo, the tsetse fly is fatal to cattle over a large area. Outside the Union of South Africa, the principal concentrations of cattle on the African continent occur in the highlands of Ethiopia and of northern Tanganyika, Kenya, and Uganda.

In the Western Hemisphere most of the cattle within the torrid zone are concentrated in the highlands of Brazil, Colombia, Mexico, and Venezuela. In these areas altitude gives relief from tropic heat, and better pasture abounds. Nearly two thirds of Brazil's 55 million cattle are found on the plateau lands extending from southern Goiás and Minas Gerais to the southern tip of the nation. Every year many cattle are shipped from the poorer grasslands of the interior to be fattened in the cornlands of São Paulo and Minas Gerais. The best cattle and the best beef are produced in Rio Grande do Sul, Brazil's southernmost and coolest state.

Although many tropic countries export hides and skins, very few are exporters of beef Of the many nations that lie between Argentina and the United States, only three export beef, namely, Brazil, Mexico, and Paraguay. Within the torrid zone are large savannas, where beef-cattle production may increase in the high-priced future, such as the campos of interior Brazil, the llanos of Venezuela, and the savanna lands to the north and south of the African rain forest (see map inside front cover). The harsh grasses of the savannas are now being grazed by inferior native stock and are not suited to the purebred cattle of the temperate zone.

Asiatic cattle. The Republic of India is a bovine statistical paradox. In 1953 India had 193 million cattle, including about 45 million water buffaloes, or approximately 160 cattle per square mile. India leads the world in total number of cattle and in number per square mile, but her total production of meat is surpassed by at least 9 nations, and her consumption of meat per capita is extremely low, amounting to only 5 pounds a year (see Table 12:2). Meat is a luxury in the midst of poverty. Furthermore, at least 85% of India's 357 million people are Hindus, who are forbidden by religion to slaughter animals or to eat meat. Hence, most cattle in India die of old age. Being sacred, or almost so, they must not be disturbed, and the way they take their ease in the streets of the towns gives the Westerner a chance to contemplate a new set of values.

In India, Pakistan, China, and other countries of the Far East few cattle are kept for meat or milk. In vast areas man must toil in the fields from dawn to dusk, and the daily output of work depends upon human labor that is sometimes aided by the energy of draft animals. Cattle are prized for their capacity to do work, and there are special draft breeds that command a higher price.

The tropics and our own South have a possibility of meat increase, and perhaps of milk increase, by breeding from the Indian Zebu—an animal that can sweat and also be crossed with common cattle. A promising new cross-

bred beef breed named Santa Gertrudis has been produced in Texas (see Fig. 219 right).

4. SWINE (HOGS)

Qualities and distribution of the hog. The aboriginal hog was a native of the Eurasian forest. He lived upon acorns, nuts, roots, grubs, berries, dead animals, snakes, and other edibles that he found upon or under the forest floor. He converted the abundance of feed in autumn into a layer of fat that carried him through the hungry time of winter. Since his stomach was small, he could not subsist entirely upon a diet of bulky grasses. Unlike the cow, sheep, and goat, the hog did not become a denizen of the world's grasslands.

In domestication the hog is tame, harmless, hardy, omnivorous, and fecund.[11] He is still fond of the nuts and acorns of his original forest home, and his small stomach demands similar concentrated feedstuffs. The rich grains of the farm suit him exactly. He loves potatoes. He is an admirable scavenger, consuming weeds, garbage, and even animal and human waste. This catholicity of diet may partly explain a higher meat yield for feed consumed than is given by our other farm animals. It explains the wide distribution of the hog today and his great local importance as human food in many countries where commercial production of hogs is negligible.

Hog production is of outstanding importance in (1) the American Corn Belt, (2) the potato- and barley-producing countries of Europe, (3) the corn-growing land of southern Brazil, and (4) China, where the hog is the scavenger par excellence. Six nations now possess more than 60% of the world's hogs. In some areas the hog is conspicuously absent because of religious taboo, notably in lands where the Moslem and Orthodox Jewish faiths prevail (see Fig. 226).

Nomadic hogs. Nearly 10% of the hogs in our southern states root for a living in the forests of the Appalachian and Ozark highlands and of the Atlantic and Gulf coastal plains. Many hogs spend the entire year in the forest and are rounded up in early winter when they are fattest. Labor and feed costs are virtually nil, but the "soft pork" of these mast-fed hogs brings a low price. In some areas the hogs are fattened on grain, soybeans, or peanuts prior to slaughter. These hogs that roam in the forest have distinctive holes or slits in their ears to identify their owners, much like branded cattle on the western range.

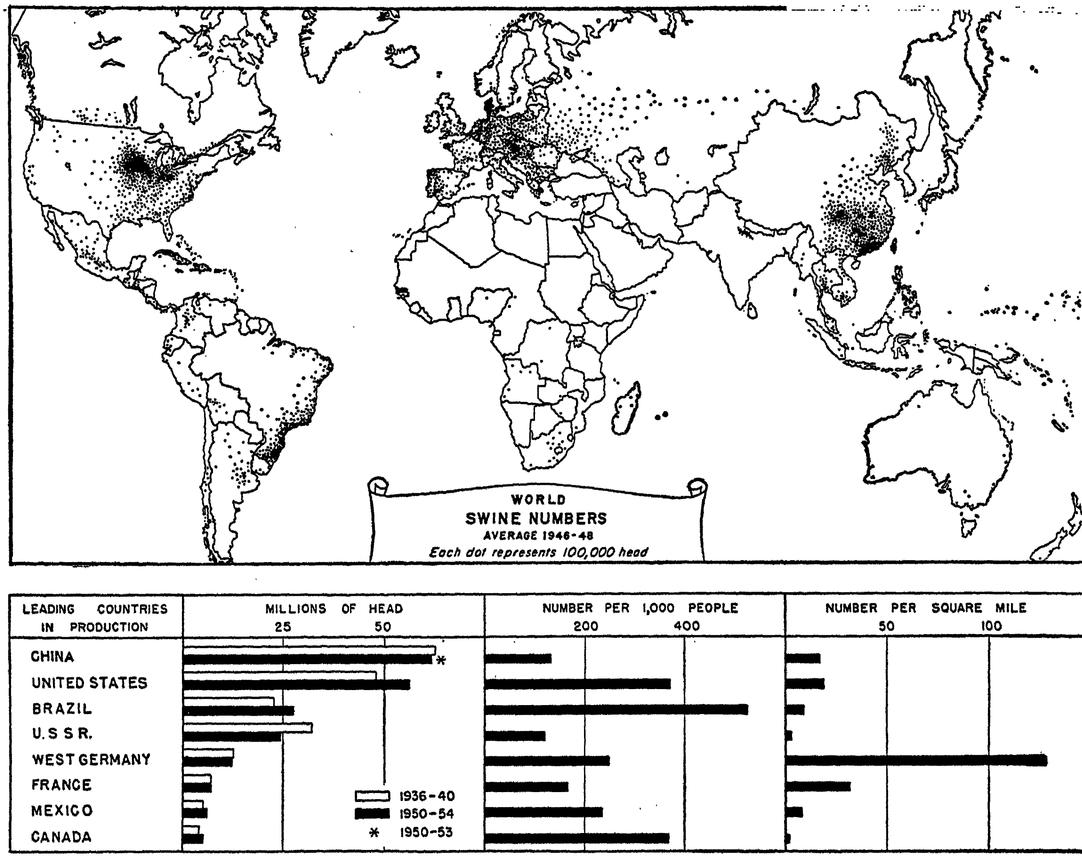
The razorback hog is an agile comrade of the southern mountaineer. This long-nosed, sharp-toothed, muscular beast is better known for his speed, dexterity, and ferocity than for his pork-producing capacity.

The nomadic hogs of Europe are more gentle than their American cousins. They are tended by swineherds, each drove of about 500 hogs traveling through the forest in autumn on a well-conducted tour. The swineherd guards against damage to the forest, and he knows the location of the best feed and water supplies. The hogs know the sound of the swineherd's horn and seldom go astray. Mast feeding is common in the oak and beech forests of Central Europe and the Balkans and in the cork-oak forests of Portugal and southwestern Spain.

Corn-fed hogs. The American Corn Belt is a kingdom of hogs, possessing about 60% of all hogs in the United States. Indeed, Iowa and Illinois together produce more hogs every year than any foreign country except China, Brazil, and the Soviet Union. Although many Corn Belt hogs are kept in barnyards and are fed during the morning and evening chores, most hogs are now sheltered in large houses near the corncrib in winter and in movable sheds in the fields in summer. Each sow and her litter have individual quarters to prevent overcrowding. In a land where labor is costly, self-feeders are in common use.

The corn-fed hog is a fat cylindrical hog, each pound of pork being the equivalent of 5½ pounds of corn. The Corn Belt farmer no longer specializes in lard hogs, because the

[11] It is a rare flock of sheep that doubles itself in a year, while a tenfold increase or more of swine is common. For animal "facts of life," see Zimmermann, *op. cit.*, pp. 305–308.



Note and explain the wild differences in rank of nations in the three columns. ***U. S. Department of Agriculture***

demand for lard has declined as a result of competition from vegetable fats and oils. Today he usually produces intermediate or combination breeds that yield more hams, bacon, pork chops, and other pork products and less lard. The American corn-fed hog has his counterpart in southern Brazil, the Danubian countries, Manchuria, and other corn-growing lands.

Skim-milk- and potato-fed hogs. There is no better feed for growing pigs than skim milk combined with corn, barley, or mill feed and a little alfalfa or clover hay. Hog production is often important in areas that grow little or no corn, as in the dairy sections of Minnesota, Wisconsin, southern Canada, and northwestern Europe.

Northwestern Europe has long been a great hog producer. The hogs are less fat than corn-fed hogs, and they are specialists in the production of bacon and ham. They are fed on barley, potatoes, and skim milk, a diet that is sometimes supplemented with imported corn, particularly in Denmark and Ireland. Like European beef cattle, the hogs spend much of their lives in barns, a single barn containing as many as 300 hogs. The hogs are fed three times a day. The Danish hog is the best scrubbed hog in the world, being washed and brushed almost daily. Such a system, with its emphasis on quality, works well where land is costly and labor is cheap.

Tasty Danish and Irish bacon, with its streak of fat and streak of lean, has long been the favorite on the British breakfast table. Little Denmark leads the world in the export of bacon and ham.

Scavenger hogs. The hog is an efficient redeemer of waste. Many American cities turn over their garbage under contract to collectors,

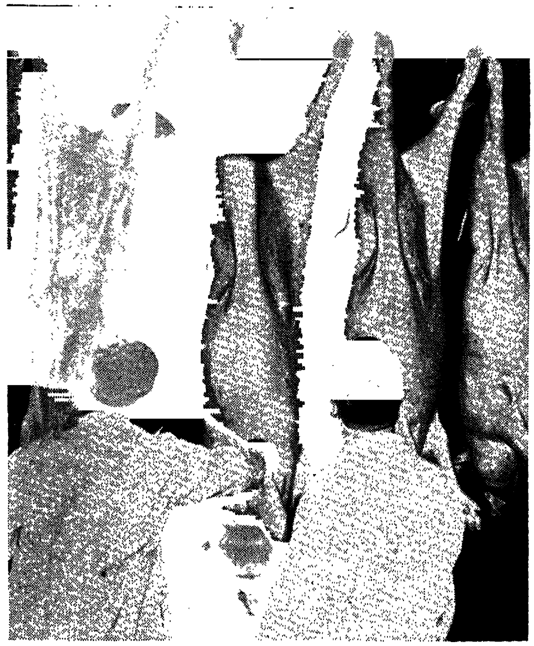
who sell it to hog farms. When this is done, city dwellers are required to remove inedible objects. Northern New Jersey has a sizable hog industry dependent upon urban garbage, although the price paid for garbage-fed hogs is less than the price paid for their corn-fed brethren.

It is probable that China leads all nations in number of hogs (see Fig. 226), and in China the hog achieves his greatest triumph as a scavenger. In this crowded, poverty-stricken land meat is a luxury, and an occasional festival meal of chicken or pork is the only meat known to millions. The tiny farm that cannot afford a sheep, cow, or ox usually has a few chickens and a hog—an animated, productive, and edible garbage can.

5. MEAT PACKING

The U. S. meat-packing industry. A century ago meat packing involved nothing more than salting meat and packing it in barrels. It was not until the 1870's that the perfection of the refrigerator car made possible the long-haul transportation of fresh meat. Since then the American meat-packing industry has become one of the world's largest industries, converting millions of bellowing and squealing animals into meat and a host of by-products. In 1953 more than 76 million hogs, 34 million cattle and calves, and 16 million sheep and lambs entered some 3400 slaughterhouses scattered throughout every state of the Union.[12]

About 62% of all livestock production occurs west of the Mississippi River, and about 69% of all meat is eaten in the more densely populated area east of the river. This simple fact, together with the outstanding importance of the Corn Belt as a producer of hogs and beef cattle, goes far to explain the preeminence of Illinois, Iowa, and other north-central states in the meat-packing industry and the leadership of a few cities in livestock receipts (see Table 12:6).



On the way to many pieces. *Swift & Co.*

Chicago, the meat capital. Four peerless assets have contributed to the supremacy of Chicago, which has led the nation in meat packing since 1861, when it surpassed Cincinnati. First, Chicago is located roughly midway between the production of livestock and the consumption of meat. Second, from the beginning, the city was a major railway center with excellent assembling and distributing facilities. Third, Chicago and its neighboring cities provide a big market for by-products, hides being sold to tanneries, wool to textile mills, glandular products to pharmaceutical factories, etc.[13] Fourth, like all big cities, Chicago has many poor people and therefore a large market for the cheaper and less desirable cuts of meat.

Other packing centers. Omaha, Nebr., East St. Louis, Ill., and South St. Paul, Minn.,

[12] Although some of these plants are engaged only in slaughtering, fully 90% of all meat is produced in plants that pack and cure meat, process by-products, and manufacture sausage. In addition there are about 11,000 butchers, each slaughtering less than 300,000 pounds live weight annually. American Meat Institute, *Facts and Figures about the Meat Packing Industry and Its Products*, Chicago, 1954, pp. 11, 23.

[13] To make 1 ounce of insulin, pancreas glands from 7500 hogs or 1500 cattle must be saved and properly processed.

have become serious rivals of Chicago, and lesser meat-packing centers have arisen in importance. The trend toward decentralization has been stimulated by the increased use of motor trucks, enabling farmers to deliver livestock to nearby packing plants in better condition. Most meat-packing plants are located in cities near fattening grounds to prevent loss of weight en route and to avoid freight charges on waste material that forms a large part of each animal. Meat accounts for only 45% to 50% of the live weight of sheep, 50% to 55% of cattle, and 70% to 75% of hogs. As yet, nobody has perfected a utopian sheep or steer, or a hog that is all pork chops, pork roast, bacon, and ham.

A marvelous plant. The modern meat-packing plant is a marvel to match the automobile factory, the chief distinction being that meat packing is a disassembling industry. At the end of its last mortal mile, a steer gets bumped on the head with a mallet and stuck underneath with a knife, and the lifeless body travels on a trolley between a long row of men, each with a definite task to do. Eventually the steer leaves the plant as carcass beef, glue, soap, fertilizer, poultry feed, oleomargarine, and many other things.

TABLE 12:6. Millions of Livestock Received at Leading Markets, 1952

City	Total	Hogs	Cattle and calves	Sheep and lambs
Chicago	6.7	3.9	1.9	.9
Omaha	6.2	3.0	2.0	1.2
East St. Louis ..	5.3	3.2	1.4	.7
South St. Paul..	5.1	3.1	1.3	.7
Denver	4.1	1.2	1.0	1.9
Sioux City	3.9	2.5	1.4	..
Kansas City	2.6	..	1.9	.7
Indianapolis	2.4	2.4	..	..
St. Joseph	2.4	1.8	.6	..
Fort Worth	1.9	..	1.0	.9
Ogden	1.2	..	..	1.2
Peoria	1.2	1.2	..	..

Source: Adapted from American Meat Institute, *Facts and Figures about the Meat Packing Industry and Its Products,* Chicago, 1954, p. 20.

Four big packers. The American meat-packing industry is dominated by the Big Four meat packers—Swift, Armour, Cudahy, and Wilson—who enjoy the advantage of a buyer's market when they buy their livestock and a seller's market when they sell their meat. When the Big Four buy livestock, they bargain with millions of unorganized farmers and ranchmen scattered throughout the land. There is keen competition among farmers and ranchmen, who are eager to sell the livestock that have been fattened and are ready for sale. On the other hand, when the Big Four sell meat through branch houses and retailers to millions of housewives, they are in no hurry to sell. The purchasers, however, want their steak or pork chops tonight and not at some distant date. Coming and going, the Big Four are on the "long end" of the stick.

Meat packing in foreign lands. Modern meat-packing plants have arisen in many parts of the civilized world. Toronto and Winnipeg have become the Canadian counterparts of Chicago and Omaha. Meat packing is well developed in western Europe, the Soviet Union, and in the great meat-exporting countries of the south temperate zone.

In western Europe the assembly of livestock and distribution of meat involves a much smaller haul than in the United States. Meat-packing plants are smaller, and the country butcher plays a larger role. In the vast Soviet Union meat-packing plants are large, widely distributed, and oriented in terms of railway transportation since highways are poor. Meat, however, is a semi-luxury for most Russians.

In Australia, New Zealand, southern Brazil, Uruguay, Argentina, and Chile the principal meat-packing plants are located at tidewater or not far from the sea. In none of these countries is the chief livestock-producing region so far from the ocean as in the United States. In all of them the big domestic markets, or urban centers, are along or near the seacoast. Thus, Argentina's largest meat-packing plants are located upon navigable water at Buenos Aires, Rosario, and La Plata, where they can easily serve both domestic and foreign markets. Some packing plants, it is true, have arisen in remote locations, as at Punta Arenas, the world's southernmost city, on the Strait of Magellan.

13· Dairy Products, Vegetable Substitutes, and Small Animal Industries

1. THE DAIRY INDUSTRY

Dairy cattle and dairy products. Milk, intended by nature only for the offspring of the particular species producing it, has been taken by man at various times and places from camels, mares, sheep, goats, reindeer, cows, yaks, water buffaloes, and other animals. As a result of long selection and improvement, the goat and the cow have become especially adapted for this service and give quantities of milk that would have astonished our primeval ancestors who first domesticated the animals.

By artificial selection the breeds of domestic cattle have been specialized into two broad classes of different-shaped animals: the beef animals that get fat if well fed, and the dairy or milk breeds that give much milk if well fed (see Figs. 218 right, 230). The leading breeds of dairy cattle on American farms originally came from Europe—the Holstein-Friesian from the Netherlands, the Guernsey and Jersey from the isles of Guernsey and Jersey in the English Channel, the Ayrshire from Scotland, and the Red Swiss from Switzerland. The Holstein-Friesian cow is champion in volume of production, a purebred prize winner yielding more than 6 tons of milk per year. The average American cow, however, has a more modest yield of about 2½ tons annually.

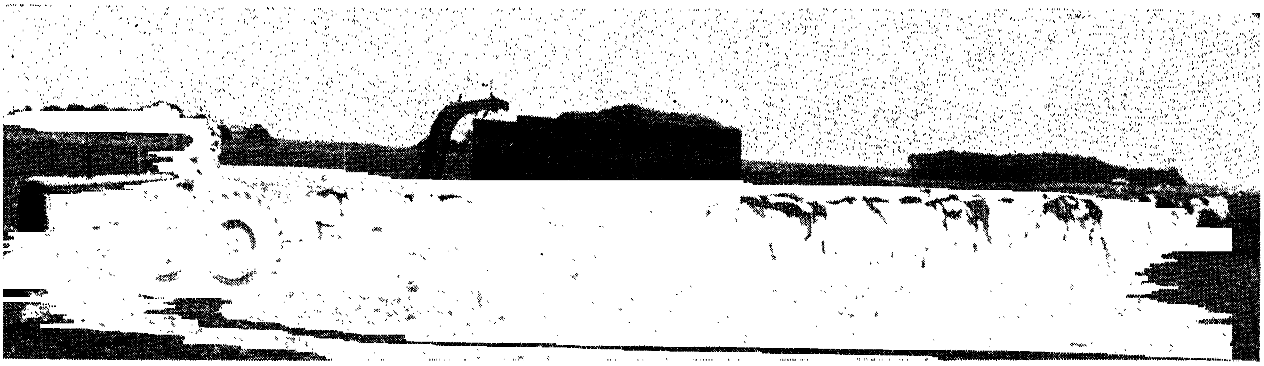
Food values of dairy products. Milk is a perfect food, in that it completely sustains life, but dangerous because of the ease of contamination in its collection and the further fact that it is a perfect germ culture. Fortunately, state laws and regulations in this country insure the delivery of clean and healthful milk. Cheese ranks high in protein and is a substitute for meat, while butter is a fat, supplying well the deficiency of the albuminous and starchy foods. We are just beginning to learn the true values of food (see Table 12:1).

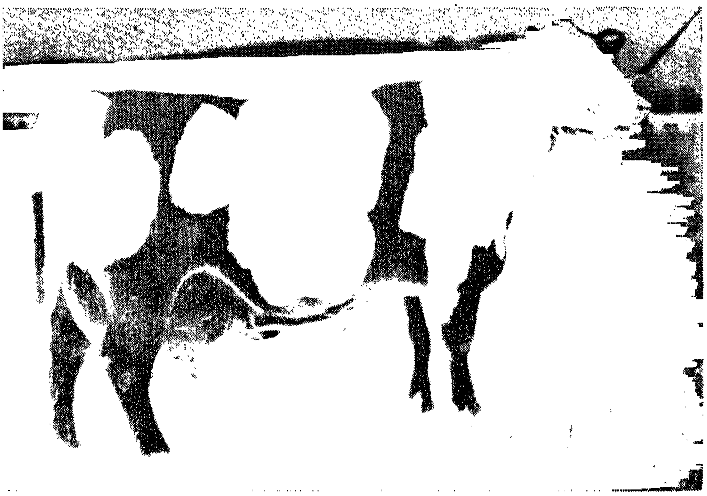
The principal dairy products used by Americans are fluid milk and cream, ice cream, evaporated and condensed milk, butter, and cheese. The per-capita consumption of dairy products continues to increase, with the notable exception of butter, which has been

TABLE 13:1. Per-capita Consumption of Dairy Products in the United States
(pounds)

Product	1914	1939	1952
Fluid milk and cream	321.0	332.0	352.0
Ice Cream	3.4	10.8	17.5
Evaporated and condensed milk	8.8	17.6	17.4
Butter	16.7	17.2	8.7
Cheese	4.1	5.8	7.7
Nonfat dry milk solids	...	2.1	4.4
Dry whole milk	0.1	0.1	0.4

Source: USDA, *Agricultural Statistics, 1953,* pp. 427–429.





(Above) **Machinery for grass farming may keep corn, a tilled row crop, from causing erosion on millions of hills. Central machine—field harvester—cuts a grass crop, chops it fine, blows it into wagon. One man. Wagon a self-feeder. Cows pull grass out at bottom of bed, or grass may go to silo. See how cows follow the grass wagon, eating as they walk!** ***Lundell, Cherokee, Iowa.***

(Left) **Champion dairy cow gave 36,414 lbs. of milk in 365 days; ate pounds: grain, 7300; corn silage, kale, beets and cut grass, 48,185; alfalfa hay, 12,775. In pasture 3 hours daily for 6 months.** ***Carnation Milk Farms***

hurt by the competition of oleomargarine (see Table 13:1). Approximately 53% of our annual production of some 58 million tons of milk is consumed as fluid milk and cream, 24% is used in making butter, 10½% in cheese, 6% in canned milk, 3½% in ice cream and minor products, and 3% as feed.

Dairying: intensive agriculture. Dairying is an important step in the intensification of agriculture, the dairy farm producing a much larger income per acre than a wheat farm or a cattle ranch. The American dairy farm is small, averaging 120 acres in size. A dairy herd requires constant care, and purebred cattle are expensive. Much labor and capital can make a little land yield a large return. Hence, dairying succeeds not only on high-priced land surrounding urban areas but also on land that is too rugged, too unfertile, or too cool for corn or winter wheat, as on the farms of New England, northern New York, and the mountain valleys of our Pacific states.

Today machines imitate the action of the calf's tongue and the milker's hand. Electricity furnishes the power, and thus most of America's commercial milk is a machine product. The machine doubles a man's speed.

The U. S. dairy industry. Fluid milk is 87% water and the most difficult of all dairy products to ship. It is generally a short-haul commodity because of its perishability and its low value in proportion to great bulk and weight. In recent years the motor truck and modern highway have greatly facilitated the transportation of market milk, and dairy farms are now found around nearly every city and town.[1]

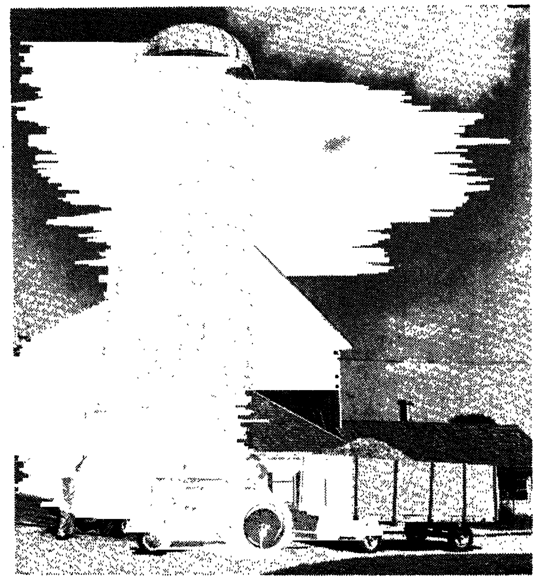
[1] The Babcock milk tester for determining the cream content of milk, the power-driven cream separator, the milking machine, and the motor truck have helped to usher the dairy farm into the Machine Age.

The optimum development of dairying occurs in areas that are endowed with abundant rainfall, cool summers, succulent grass, adequate labor, and easy access to large urban markets. For the most part, the U. S. Dairy Belt is such a region—a crescent-shaped region extending from Minnesota and northeastern Iowa through Wisconsin, Michigan, Pennsylvania, and New York into New England and including parts of northern Illinois, Indiana, and Ohio. In general, the eastern portion of this region now specializes in market milk, while most butter and cheese is made in the western part. Proximity to market is the region's greatest asset.

The Chicago metropolitan area obtains its fresh milk chiefly from Wisconsin. Detroit draws upon lower Michigan. Cleveland and Pittsburgh depend upon the farms of eastern Ohio and western Pennsylvania. Philadelphia is served by the dairies of Pennsylvania, Delaware, and Maryland. New York City obtains nearly all its milk from New York state, eastern Pennsylvania, and northern New Jersey, while the Boston milkshed includes all New England (see Fig. 232 right).

Ice cream—nearly 600 million gallons of it—is consumed by the American public annually. Ice cream plants, large and small, are scattered across the nation. States with big populations lead in ice-cream manufacture, namely, Pennsylvania, New York, California, Ohio, Illinois, Michigan, and Texas. Ice-cream cones were first manufactured in St. Louis at the World's Columbian Exposition in 1904 and, like hot dogs, have become a typical American institution. More than 4 billion ice-cream cones are sold annually.

Butter is the solidified fat of milk that is obtained from cream by churning. At one time, most of the nation's butter was country butter, churned on the farm. Today nearly all butter is manufactured in creameries. As sour milk may be used, deliveries to creameries can be made once or twice a week. Some creameries are found in areas with poor local transportation, but most of them are located on the margins of important dairy regions where they do not compete with fresh milk

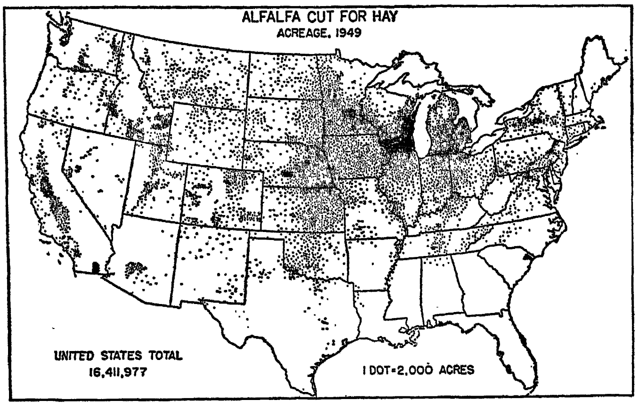


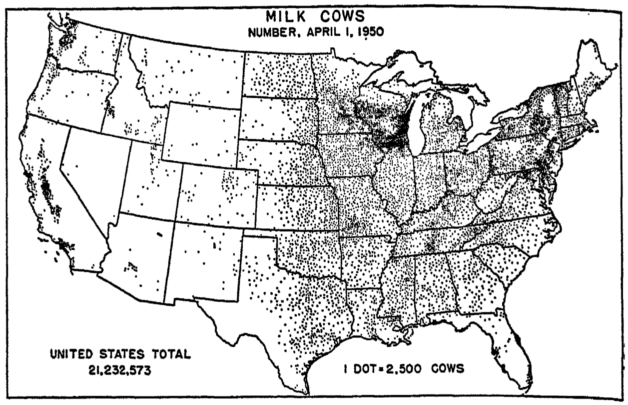
Silo, backbone of U. S. dairy farm. Field harvester loads wagon with chopped grass, corn, sorghum, beans. Device by man at left blows contents of wagon to top of silo. ***John Deere***

destined for urban markets. The tri-state region of eastern and southeastern Minnesota, northeastern Iowa, and western Wisconsin produces more than 45% of the nation's creamery butter. Because of its value, butter can travel long distances, and it may be kept under refrigeration for a long time without deterioration.

Cheese is made from the thick part of milk, it can be easily stored, and it is often transported great distances. Since milk for a cheese factory must be absolutely fresh, the factory

Hay baler, friend of dairyman, reduces farm labor—and farm population. ***John Deere***





(*Left*) Alfalfa locates the main irrigated spots west of the Wheat and Sorghum Belts. (*Right*) Test yourself. Explain concentrations. *U. S. Bureau of the Census*

is located near the raw material. The United States has more than 6500 cheese factories, most of them small. No state rivals Wisconsin, which manufactures one half the nation's cheese, most of the remainder being produced in New York, Illinois, Missouri, and Minnesota. Wisconsin's pre-eminence is due not only to low summer temperatures and good pasture but also to long experience in cheese-making and aggressive advertising of brand names.

Evaporated and condensed milk are fresh milk from which 60% of the water has been removed, condensed milk being sweetened prior to canning. Milk-canning plants, or condenseries, are much larger than creameries and cheese factories. They require large and dependable milk supplies, and most of them are located where dairying is developed on a large scale. Wisconsin, California, Ohio, and Michigan account for about one half the nation's production of canned milk, a product that will keep indefinitely and can be shipped to the four corners of the world.

Canadian dairying. That part of Canada lying between Lake Huron, the city of Quebec, and the United States boundary, comprising the populous parts of Ontario and Quebec, is like Wisconsin and New York in its inability to compete with the level West as a grower of either corn or small grain. Consequently, the people have long since turned to dairying and have reached a high degree of success through skillful use of state instruction and inspection. Great care is taken to maintain the high quality of the product, and Canadian cheddar cheese is much esteemed in the United States. Canada now imports more cheese than it exports.

Dairying in northwestern Europe. Northwest Europe, with its cool moist climate, luxuriant grass, abundant labor, and huge urban markets, has every requirement for a great dairy region, and the scarcity of meat causes cheese to be used far more than in meat-eating America. The farms of northwestern Europe are small, and in no other part of the world has dairying been developed more intensively. Although grain is grown on most farms, imports of grain, cottonseed meal, soybean meal, and other feedstuffs are often necessary.

In 1952 the leading producers of butter were the United States, West Germany, France, New Zealand, and Denmark. In the production of cheese, the United States was followed by Italy, France, West Germany, and the Netherlands. Tables 13:2 and 13:3 reveal the importance of European countries in the international trade in butter and cheese. The rich pastures of Great Britain support an important dairy industry, and about 80% of the domestic milk supply is sold as fresh milk to city dwellers. Great Britain imports 100 to 150 million pounds of canned milk a year and has long led the world as an importer of butter and cheese. Eire, a large butter exporter in prewar years, now imports

TABLE 13:2. International Trade in Butter in 1952
(millions of pounds)

Country	Exports	Country	Imports
New Zealand ..	360	United Kingdom	581
Denmark	251	Belgium-Luxembourg..	59
Netherlands ...	110	Italy	41[a]
Australia	73	France	33
Sweden	29	Germany, West.	20
Finland	9	Switzerland ...	16
Norway	4	Eire	14
Germany, West.	3	Union of South Africa	6

a Data as of 1951.
Source: USDA, *Agricultural Statistics, 1953,* p. 432.

TABLE 13:3. International Trade in Cheese in 1952
(millions of pounds)

Country	Exports	Country	Imports
New Zealand ..	206	United Kingdom	307
Netherlands ...	172	Germany, West.	90
Denmark	119	Belgium-Luxembourg .	71
Australia	57	United States ..	49
Switzerland ...	44	France	37
Italy	43	Italy	30
France	39	Canada	12
Finland	21	Sweden	10

Source: USDA, *Agricultural Statistics, 1953,* p. 436.

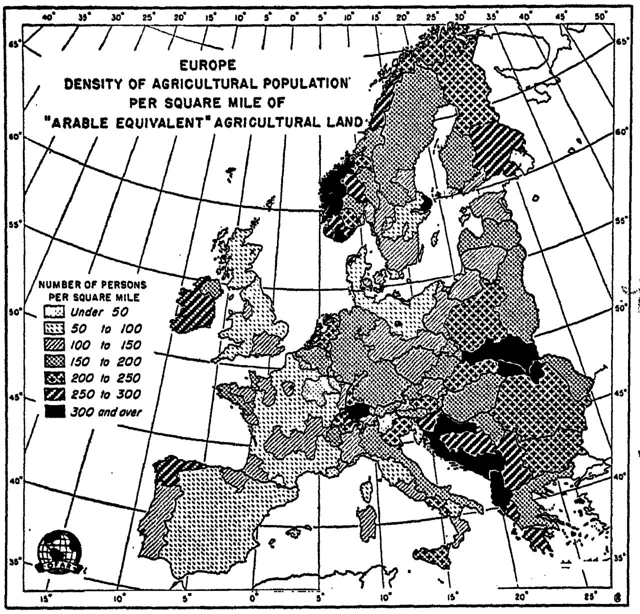
butter. It helps to supply Britain with canned milk, and some of its fresh milk is shipped by fast vessels to Holyhead, Wales, and thence by train to London.

Dairying is well developed throughout France except in the warm Mediterranean area. France exports cheese but is now dependent upon butter imports. The town of Camembert in Normandy has given its name to a well-known brand of cheese, and in the southern Massif Central is the town of Roquefort, where for generations the peasants have handed down from father to son the art of making from sheep's milk their famous cheese that is ripened in stone caverns deep under the ground.

The Netherlands ranks second only to New Zealand in cheese exports and has been famed for its cattle since the days of Julius Caesar. Meadows, which the Dutchman has won from the sea by pumping out the water, were made by the rich mud that the Rhine has brought down from fertile highlands of Central Europe. These moist, rich lands, too wet for tillage, make pastures of great richness. Here drainage ditches separate from each other the little green fields, dotted with feed boxes from which the black and white cows eat grains and other feedstuffs imported from overseas. By this means farmers increase the number of cows they can keep. Since comfortable cows give the most milk, they are blanketed in pastures during the cold rainy weather. These richly fed and carefully tended herds of Holstein-Friesian cattle are the greatest of all farm assets. The Dutch make twice as much cheese as butter, and their famous Edam cheese is sold to many foreign lands. Dutch exports of canned milk amount to nearly 500 million pounds a year.

Denmark has long taught the world how to make good butter, and it now ranks second to New Zealand in butter exports. The little country is visited by the agricultural scientists of all the world who would learn in its best form the art of dairying. This democratic kingdom has become a vast dairy farm with pig and poultry accompaniments. The Danish farmer owns a farm of from 5 to 40 acres. The land is usually sandy and was originally infertile but has been made productive by commercial fertilizer and cow manure. The Dane, like the Dutchman, makes large use of grain and other feedstuffs imported from overseas. As a result, Denmark with a poorer soil rivals Holland in having more farm animals for its area than any other country of the world.

The Danes have more than 1000 factories for making butter; the cows are inspected once a month to insure healthy stock, and the dread disease of tuberculosis, so common among housed cattle of the entire world, has been entirely stamped out of the kingdom of Denmark. The thrifty Danes import margarine to eat, and export their butter. Through careful catering to the demands of the market, Danish butter preserved in tin cans has become the standard article for consumption in



Spots with many explanations. Where is riches, poverty, machinery, mountain land? ***U. S. Department of Agriculture***

the tropics and in all the remote corners of the globe where there is no local supply.

West Germany, southern Norway, and southern Sweden also have well-developed dairy industries. Each of these countries uses about one half its milk supply in making butter. Each has perfected specialties in cheese manufacture, the Norwegian Gjetost and the German Limburger and Muenster being particularly famous. West Germany, much like urbanized Britain, is dependent upon imported butter, cheese, and canned milk to augment domestic supplies.

Switzerland has an interesting and unique dairy industry. Relatively large areas of land upon the high mountains, habitable only in summer, produce an abundance of rich grass as the melting snow recedes and lets sunshine upon the saturated earth. The villagers of the valleys take their herds of cows to the higher pastures in summer, and, because of the distance, stay with them through the whole season, spending the nights in houses that have been built for the purpose. At intervals members of their families bring up the necessary supplies and take away the accumulations of cheese and butter (mostly cheese) which the herders have produced. On the lower slopes of the Alps hay is cut with scythe in the most terrifying places and taken down by wire, sled, man back, or quadrupedal pack animal. As a result of this careful industry, Switzerland is an exporter of excellent cheese, Gruyère being one of the best-known brands. She also exports condensed milk. Milk is also an important factor in the manufacture of milk chocolate, in which Switzerland has long held a high reputation.

The Soviet Union. The great dairy belt of the North European Plain extends eastward into European Russia and western Siberia. Prior to World War I and briefly in the 1930's, Russian butter was exported to western Europe. According to one account, the Soviet Union had 24.3 million dairy cattle in 1953 as compared with 28.8 millions in 1916, and the Russian people are now getting less meat and dairy products than they did under the czarist regime.[2] Apparently, guns are preferred to butter.

Milk in Mediterranean lands. The small quantity of milk that is used, chiefly by children, in the Mediterranean countries of Europe with their summer drought is largely supplied by goats, which can live on a poorer and drier diet than is possible for the cow. Some varieties of milk goats give a greater amount of milk in proportion to their weight and food consumed than does any other animal in the world. Furthermore, goat's milk is richer than cow's milk in both fat and solids. One of the characteristic street scenes in these countries is the milkman driving herds of goats through the street and milking them at the door of the customer, being able thus to guarantee the absolute freshness and purity of the milk—matters of importance in an iceless land.

In Italy, commercial dairying is in the main limited to the irrigated lands of the Po Valley.

[2] "Russia—Retreat," *Time,* September 28, 1953, p. 25.

Italian butter imports are surpassed only by those of Great Britain and Belgium–Luxembourg. Cheaper cheeses are imported into Italy to feed her own people, just as the Dutch and Danes import oleomargarine for their own use and sell the butter that they make. Cheese exports, however, exceed imports (see Table 13:3). Among the well-known brands of Italian cheese are Asiago, Bella Paese, Caciocavello, Gorganzola, Parmesan, and Romano. The Italian people consume more than 670 million pounds of cheese annually, or about 15 pounds per capita, along with countless miles of macaroni and spaghetti.

New Zealand and Australia. The refrigerator ship which has revolutionized the meat supply has made possible the importation of butter and cheese from remote countries. Thus New Zealand, which is almost exactly on the opposite side of the world from Great Britain, has been able to attain front rank in dairying and now leads the world in the export of butter and cheese. Most of the factories are large and new, butter and cheese often being made in the same factory, and the government has taken great pains to inspect and guarantee the quality of exports. New Zealand, like Great Britain, has an ideal climate for dairying (see folded colored map at front). The westerly winds bring abundant rain, the pastures are green throughout the year. Indeed, the grass seems to grow faster than the cows can eat it.

Australia, the Texas of the Antipodes, being further north and out of the latitude of steady rains, has her production of dairy products sadly interfered with by the droughts. Consequently, the industry, less important than in New Zealand, is chiefly limited to New South Wales and Victoria, the most southerly, the coolest, and rainiest part of a warm, dry continent. In 1952 Australia ranked fourth in the export of both butter and cheese, but drought makes the quantity fluctuate.

Possible extension of dairy areas. Dairying, of all the great agricultural industries, is the most exacting in its labor requirements. The cow must be milked morning and evening the year around; she must be treated gently by a really civilized person; the cow, the product, and utensils must be kept clean. These qualities have been developed chiefly by the progressive dairymen of the United States, northwestern Europe, and Australasia. With modern refrigeration, the way is now open for the geographic extension of dairying. At the present time it is an industry largely but not necessarily restricted to the cooler parts of the world. It may become more common for the warm lands rather than exceptional, as is the present export of small quantities of native African butter, which is sent to Europe for reworking from the highlands of Tanganyika, Kenya, and Uganda.

In many parts of China and Japan dairying is almost unknown for reasons made evident in the section on meat and cattle, and any large increase is improbable, or perhaps one should say impossible.

The United States could double its output of milk if needed. Consider the achievements of Denmark. We do not export because of the cheaper manpower of Europe.

2. DAIRY SUBSTITUTES

Oleomargarine: butter's leading rival. The peoples of the United States, Canada, northwestern Europe, and other lands are using increasing amounts of oleomargarine instead of butter. This lower-priced butter substitute can now be made from many animal and vegetable fats and oils. The wizard of chemistry can extract the oil of the cottonseed, peanut, or other oily material and remove its color, odor, and flavor. He may neutralize it and blend it with other oils. He may inject some hydrogen to raise its melting point and change it into a solid. As a result, inedible materials become edible, and a large number of animal and vegetable fats and oils may now be substituted one for another in the manufacture of soap, lard substitutes, cooking oils, and oleomargarine. The greedy lard hog and the contented dairy cow have cause to worry, and their owners really *do.*

Palm-oil market, shore of Tanganyika. ***Leroy Shantz***

Among the animal products used in making oleomargarine are oleo fats, lard, tallow, and butter. In Europe the oil of the Antarctic whale is a major material. The animal kingdom, however, is losing ground in competition with abundant vegetable fats and oils.[3] About two thirds of the world's supply of fats and oils is now obtained from vegetable materials. Oils from the coconut, peanut, soybean, cottonseed, palm nut and palm kernel, rape and sesame seeds, and corn are of growing importance in making oleomargarine. Indeed, almost any vegetable fat or oil can be used, but the dairyman points to the fact that butter really has the vitamins.

In many lands butter is not available, and there is no corner grocery store or supermarket where the housewife can buy a pound of oleomargarine. In such countries, fat for the human diet is often obtained directly from local fats and oils.

Olive oil: butter substitute in Mediterranean lands. Milk production is at a low ebb in lands of little rainfall or of summer drought, such as we find in Mediterranean and other dry subtropic lands, because of the scarcity of grass. During the months of summer drought, the cost of supplying milk animals with green and succulent food is so great as to make milk relatively expensive and something of a luxury unless there is large opportunity for irrigation, and that too is costly.

Fortunately, the Mediterranean climate furnishes the fat of olive oil as a butter substitute. The countries of the Mediterranean basin produce nearly 1,120,000 tons of olive oil a year, about 43% being produced in Spain, 25% in Italy, and most of the remainder in Greece, French North Africa, Portugal, and Turkey. Butter production in these countries is almost nil except in Italy, which produces about 135,000 tons a year. Hence, olive oil is commonly used in cooking and is even spread on bread.

The olive is a wonderful food producer. It grows in poor, rocky hillsides from Gibraltar to Jerusalem and from the Sahara to southern France. Its oil, unlike most of the animal fats, does not easily become rancid.

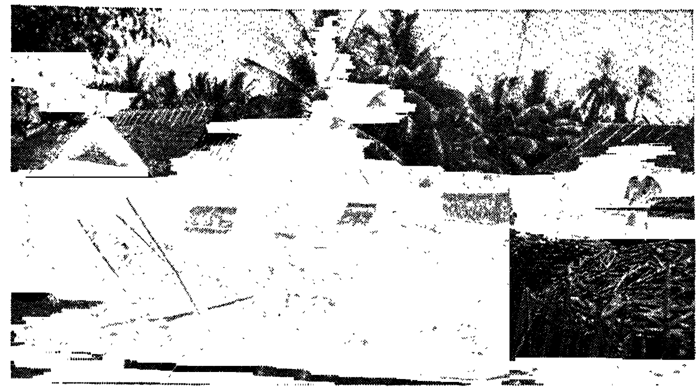
We have seen prosperous trees thriving in the gulches of central Tunis, where the rainfall was only 7 inches per year. And we have seen bearing and prosperous Tunisian trees that undoubtedly were planted before the incursion of the Arabs in 648 A.D. This lends possible truth to the legend that the olive trees under which Jesus walked in the Garden of Gethsemane may still be standing. They look as though they were.

Vegetable oils in the rainy tropics and subtropics. The hot and rainy regions of the earth favor neither the white man nor his milk-giving animals. For the production of dairy substitutes, however, the tropics are well fitted—except for the matter of vitamins. Butter and cheese are but digestible fat and protein plus the indispensable vitamins. Many vegetable oils furnish very similar fat, and there are many cheaper proteins than cheese. Two promising dairy rivals are found in the oily coconut and the nutritious peanut.

---

[3] The uses of animal and vegetable fats and oils are legion. Competition is keen and complex. See Erich W. Zimmermann, *World Resources and Industries,* rev. ed., Harper & Bros., New York, 1951, pp. 260–287.

Celebes, Indonesia. Coconut, often the first export of rainy, tropic shore 20°N. to 20°S. *Wm. H. Koenig*



The coconut. The coconut palm is at present the leading source of vegetable oil. It grows wild upon thousands of miles of tropic seashore, and it succeeds at inland locations where environmental conditions are favorable. The tree thrives in areas that have 60 to 100 inches of rain well distributed throughout the year, in temperatures ranging in the high 70's and 80's, and in sandy soils with good underdrainage. About half the meat of the coconut is fat, and the tropic native relishes the coconut's fresh meat and milk. Copra, the dried meat of the coconut, will keep for months without becoming rancid.

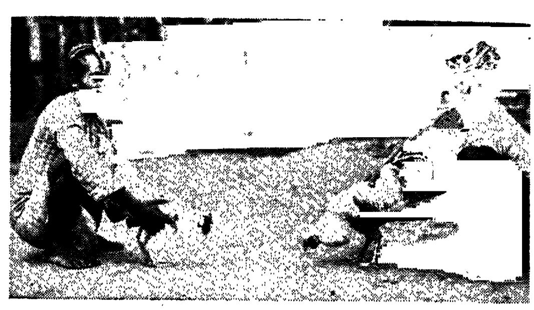
A good coconut tree will produce 50 to 180 nuts annually; 4000 to 7000 nuts make a ton of copra, yielding 100 gallons of oil. The food possibilities of coconut growing sound almost too good to be true. "When his coconut trees begin to bear, he hangs up his hammock"—tropic adage.

Coconuts are collected by natives and sold to traders in many parts of the tropic world, and large coconut plantations have been established with the aid of European and American capital. Every year large quantities of copra and coconut oil are shipped from Indonesia, Ceylon, Malaya, and the islands of the South Pacific to European markets, and from the Philippines to the United States.

The peanut. The peanut may be considered as a partner of the coconut in this vegetable onslaught on the animal industries. It has gone from the peanut roaster on the sidewalk into the 8-story factory and has become a staple and increasing article of food and a staple cooking fat. The peanut per pound is nearly as nutritious as cheese, contains more protein than a pound of sirloin steak, plus more carbohydrates than a pound of potatoes, plus one third as much fat as a pound of butter. It has more nourishment than a pound of sirloin steak and a pound of white bread combined (see Table 12:1).

Now that we are in a period when growing population and high prices force us to look about for new food sources, the peanut offers a most valuable addition to our diet and to the diet of our animals. In Europe its chief use is in the form of edible oil, taking the place of lard, butter, and olive oil, for which it is now one of an increasing number of substitutes. A bushel of peanuts weighing 30 pounds (hulls included) will produce 1 gallon of edible oil when crushed, and 20 pounds of cake, a stock feed high in protein and especially suited for dairy cows and the feeding of growing animals.

The fact that this leguminous plant is at home from 37°N. Lat. clear into the south



Emotional value—to score of millions, Southeast Asia and elsewhere. A special breed. Philippine cockfight excitement surpasses any other we have seen. *Wm. H. Koenig*

temperate zone, and can be grown successfully in sandy soils of low fertility, marks it as one of our greatest crops for the future. It has already become a staple in the agriculture of our southern states. Georgia, North Carolina, Virginia, and Alabama account for 85% of all peanuts that are picked and threshed in this country.[4]

The world's peanut crop amounts to more than 10 million tons, only 8% being produced in the United States. Peanuts are exported from India, French West Africa, Nigeria, Uganda, the Belgian Congo, Indonesia, China, Manchuria, and other lands. It is perhaps our most catholic crop. Is there another that is produced and sold by the white, black, yellow, and brown races? Like the coconut in its husk, the unshelled peanut keeps in perfect condition and can wait while man takes his time to prepare and ship. Any patch farmer can grow them. These two nuts are an admirable example of the shift from animals to plants as a source of food supply, and the shift of support from cool to warmer lands.

Palm oil. The alaesis, or Guinea oil palm, grows wild in the equatorial rain forest adjacent to the Gulf of Guinea. Many a small farm has a grove of oil palms providing the native with food and a good cash crop. Palm oil from the nut and palm kernels rich in oil are exported in large quantities from Nigeria, the Belgian Congo, and other European colonies. The Guinea oil palm has been introduced into Sumatra, where production is conducted as a plantation enterprise.

The shea and other nuts. The shea nut of interior Nigeria is as prized as a butter material as is the palm nut along the coast, and it, too, has entered commerce. Likewise, the Brazilian babassu nut and the sesame and rape seeds of China and India are of growing importance. Patently, man's conquest of the oily wealth of the rainy tropics has scarcely begun.

Cottonseed. Cotton and its by-product, cottonseed, are produced in the tropics and the warmer portions of the temperate zone. At one time cottonseed was a waste product, the main problem being how to get rid of it at the least expense. Then chemical research showed that the seed contained a valuable food oil and that the cottonseed cake left after the oil was pressed out made a nutritious stock feed. The manufacture of cottonseed oil is now an important industry throughout our South, about 5½ million tons being crushed annually. A ton of cottonseed makes from 36 to 40 gallons of oil, of which about 20% is made into oleomargarine. It resembles olive oil in food value and is sometimes refined and used as a salad oil. The United States and Brazil export cottonseed oil, Pakistan exports cottonseed, and Egypt exports both.

Vegetable oils of the temperate zone. Although the rainy tropics are the most prolific source of vegetable oils, they do not have a monopoly. The United States is a producer of corn oil, and edible oil is now being extracted from sunflower seeds in the Soviet Union, Great Britain, West Germany, and China. The soybean is a major source of vegetable oil (see pages 129–130).

3. POULTRY AND SMALL ANIMALS

The importance of poultry. If you say something about gold, silver, or wheat in an assembly of businessmen, they pay respectful attention. Say "hens," and they grin. Yet the hens' output, reduced to dollars, makes gold and silver combined look like small potatoes—very small ones.

The industrious hen should not be underestimated. In 1952 the gross income from chickens and eggs in the United States amounted to $2,618 millions. In comparison, our 1.3 billion bushel wheat crop was worth $2,699 millions, while the value of all gold and silver mined in the United States was

[4] In some parts of Georgia, Alabama, and Virginia peanuts and corn are planted in alternate rows, and in the autumn the hogs are turned into the field to devour both crops, a practice known as "hogging down."

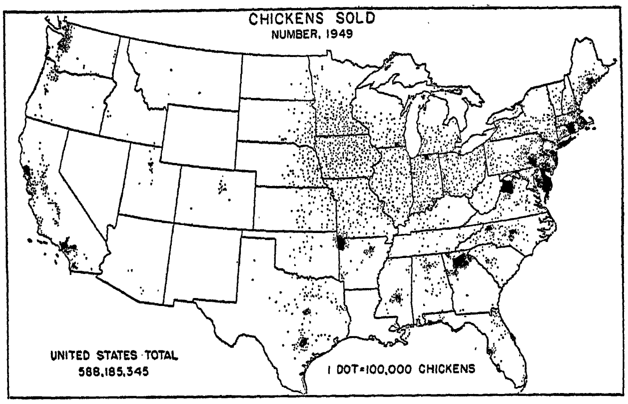
only $105 million. Indeed, a train of refrigerator cars about 3000 miles long would be needed to hold all the eggs produced on American farms in a single year.[5]

The small attention and scant respect given to the lowly hen are owing in part to the fact that she never gets on the stock ticker and doesn't lend herself to large speculations or to trusts and underwriting operations. And everyone has heard of the person who set out to make a fortune in the chicken business, plunged, and failed. The investment banker, as an investment bringer, knows not the hen. Further, legislation does not have much to do with the hen, and she plays a small part in international trade.

Poultry keeping is undoubtedly the most universal form of animal industry in the United States and also in Europe, East Asia, and various foreign countries. The names of breeds attest their world-wide distribution—Pekin, Muscovy, Rouen, and Long Island ducks; Brabrant geese, White Holland and Bourbon Red turkeys; and such diverse chickens as Brahma, Cochin, Langshan, Leghorn, Minorca, Andalusia, Hamburg, Sussex, Orpington, Wyandotte, Rhode Island Red, New Hampshire Red, and Plymouth Rock.

The American poultry industry. Fowls are kept in villages as well as on 85% of all the farms throughout the United States. They are usually a kind of by-product, often a perquisite of the farmer's wife. The very large majority of the fowls in this country are found in comparatively small numbers (about 60 per farm) on more than 4 million farms, where they gather much of their own subsistence and receive little care. The consequence is that the nearly 60 billion eggs laid annually are produced at little cost. The astounding fact is that the cash receipts from the sale of eggs amounts to about $2 billion annually.

The poultry industry spurted during World War II, as no other animal industry could spurt because of the physiological facts of re-



Broiler business strangely concentrated. ***U. S. Bureau of the Census***

production. The Machine Age has come to the poultryman, and with a little help from man, a hen may now easily have 200 children in a year. Sometimes the farmer's wife still places some eggs for hatching in the overturned barrel in the barn, but she often buys 100 or 200 downy little peepers—and they may come by parcel post. Look at the scientific hatchery, where one person operates 30,000 eggs in a mechanical incubator. It works on a very large scale and is as successful as the hen, who is now free to devote her whole time to the production of eggs. The brooder, a successful mechanical mother, has been achieved and completes the necessary equipment for large-scale production. Some farms have more than 5000 chickens. And the small operator who buys 100 or 200 chicks may raise 100% of them. She has a book to tell her how.

By-product and main product. Poultry keeping is equally well fitted to be a by-product in extensive agriculture or a main product in intensive agriculture, with a strong tendency to be important where agriculture tends to be intensive and near cities. More than one third of all chickens in the United States are located on Corn Belt farms, where feed is cheap. Outside the Corn Belt are a number of highly specialized poultry districts producing broilers for nearby urban markets,

[5] Estimate by Swift & Co., Chicago.

Mass production of turkeys, Virginia, 9000 in flock. ***U. S. Department of Agriculture***

notably in lower New England, Long Island and northern New Jersey, southeastern Pennsylvania, the Delmarva peninsula of Delaware, Maryland, and Virginia, Sonoma County near San Francisco, and Los Angeles County. All these districts depend upon grain from the Middle West, some of the larger chicken farms in California receiving carload shipments of feed at their own railway sidings.

The United States is by far the leading producer of chickens (see Table 13:4). In 1953 there were 431 million chickens on our farms, as compared with an annual average of 489 millions in 1940–49. Iowa, Pennsylvania, California, Minnesota, and Texas are now the leading chicken-producing states.

Finance has entered the broiler business. Important centers have recently arisen in Georgia, Arkansas, and Virginia, in localities where farming was not too prosperous. A banker will loan a reliable man money to buy materials for a broiler house, and the man can do much of the building himself in the course of six months. A feed dealer advances the chick money and furnishes the feed—for a share of the crop. At the end of 12 weeks the crop goes to market. Another batch of chicks may arrive the next week. It is a short-cycle business. Broiler houses are now so well planned and equipped that one man can care for 25,000 fowl.

Turkeys, ducks, and eggs. Chickens outnumber turkeys about 80 to 1; and California, Texas, Oregon, and Missouri account for about one half of our production of turkeys. Most ducks are produced in New York, notably on Long Island, and in Massachusetts, Rhode Island, and Illinois, while geese are raised chiefly in Iowa, Minnesota, and Missouri. Nearly all of us enjoy the savory meat of turkeys, ducks, geese, and chickens, but we eat few eggs except those of chickens.

Poultry in Asia. Poultry are of outstanding importance to the people of China. There, ducks and geese and chickens can serve as scavengers and save every last speck of digestible material from being wasted, and Chinese patience cares for the birds.

Years ago, the low cash wages that are often mentioned in connection with China were partly explained by the fact that in the interior of that country, eggs were 2¢ a dozen. This price helps to explain the early development by the Chinese of an export of dried eggs. The Chinese dried egg has been a staple of commerce for years. Factories on the Shantung peninsula and elsewhere convert millions of dozens yearly into dried eggs, dried yolks, and albumen (white of egg). By this means 1000 eggs can be reduced to 22 pounds' weight, easily transported, and said to keep indefinitely.

TABLE 13:4. Millions of Chickens in Selected Countries

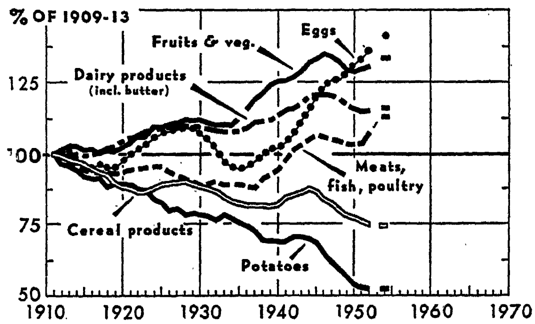
Country	1934–38 average	1952
United States	408	450[a]
China	266	195[b]
United Kingdom	73	90
Mexico	35	75[c]
France	145	70
India	[d]	66
Italy	76	63[e]
Argentina	43	60

a 431 millions in 1953.
b 1946–50 average.
c Data as of 1950.
d Not available.
e Data as of 1951.
Note: Data for U. S. S. R. not available.
Source: USDA, *Agricultural Statistics* (annual).

Dried eggs sprang into great importance in the United States during World War II for soldier food, and probably many a G. I. announced that he will never eat another scrambled egg.

The egg in commerce. The greatest peacetime commerce in eggs is in Europe. Great Britain usually imports far more eggs than all other nations combined. In recent years British imports of eggs in the shell have amounted to 100 to 150 million dozens a year and of dried and frozen egg products, about

TRENDS IN OUR EATING HABITS



Per-capita changes. Five-year moving average, symbol for 1954. All changes toward better health. See A. Davis, *Eat Right and Keep Fit,* Harcourt, Brace & Co. *U. S. Department of Agriculture*

70 to 90 million pounds. Denmark is the chief supplier, but eggs come from Italy and nearly all parts of western Europe. The European farmer finds it more necessary to sell eggs than does the American with more land, but we are tending rapidly in that direction, as shown by our great poultry increase. In 1952 American exports of eggs and egg products were equivalent to 60 million dozen eggs in the shell, as compared with annual exports of only 2 million dozens in 1932–38.

It is a perilous venture to open, at the breakfast table, an egg of uncertain ancestry. For the breakfast egg, like Caesar's wife, must be above suspicion. Denmark has taught the world how this is done. Each farmer belongs to a cooperative association. Each egg has stamped on it the number of the association, and the number of the farmer. Therefore, the British householder who breaks a bad egg can send the record straight back to Hans the Hen Grower in any corner of Denmark, and the bad egg costs him $1.38 fine. The second bad egg costs him still more, and the third is worse than three strikes in baseball, for he loses his membership in the egg association. With such attention given to the satisfaction of the customer, it is no wonder that the Danish egg has become a prime favorite in Great Britain.

U. S. copies Denmark. American farmers have taken a leaf from the Danish book. Many of our commercial eggs are now sold through

cooperatives. One Pennsylvania egg cooperative increased its business in ten years from $10,000 to $3 million. The process—every farmer's eggs are inspected, graded, and weighed, so that the buyer can know what he is getting, and daily collection guarantees freshness. Owing to the high value of output in proportion to food, we should emphasize that the distribution of the poultry industry depends more on man and less on the environment than any other of the animal industries thus far discussed.

In Germany the tractable and thoroughly domesticated goose is esteemed as the untractable and not thoroughly domesticated turkey is in America, and it is common to see boys herding them in large flocks at pasture.

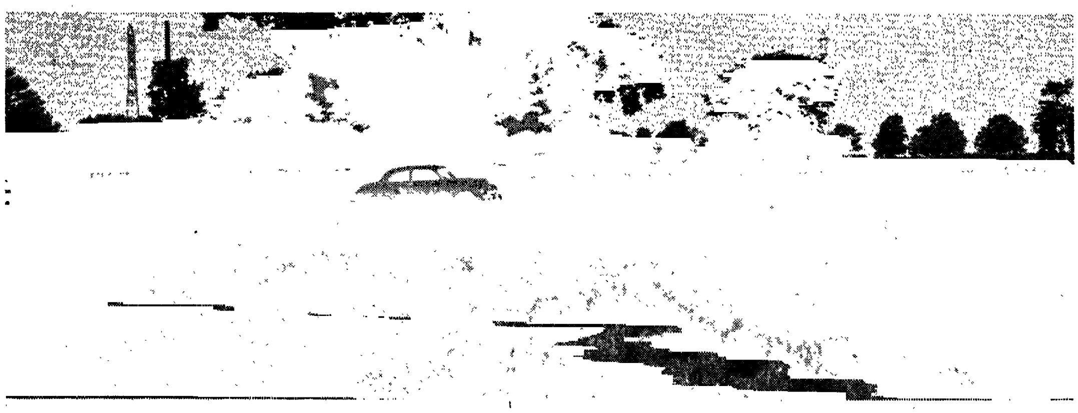
Rabbits. The rearing of rabbits and hares is common on the small farms of northern France and Belgium, whence they are exported by the hundreds of tons to Great Britain. These animals have the advantage of being able to thrive in closer confinement than poultry, and they will feed on a very wide range of vegetable food—weeds as well as hay and grains. Furthermore, they multiply fast.

Bees. Bee keeping, with its products of honey and wax, preys upon the blind thrift of an insect. Like poultry, it depends (as an industry) to an important extent upon the human element, but it also must have an environment affording nectar-bearing flowers. Where rainfall permits abundant vegetation, the tropics are the best bee lands, especially as many tropic-forest flowers are nectar bearers.

Bees are kept for their honey by the natives of every continent. Honey and wax are important exports from the Greater Antilles, and there seems to be plenty of room for extension of the industry. In 1952 there were more than 5500 bee colonies on American farms that yielded 273 million pounds of honey and nearly 5 million pounds of beeswax. The wax is used in the manufacture of floor polishes, candles, artificial fruits and flowers, ointments, facial creams, and lipsticks.

Bees are among the most highly developed of animals. The elaborate social order that prevails among the bees, even to the extent of physiological adaptation thereto, is astounding when compared to man's crude efforts. The care of bees, if well done, is one of the most scientific of the animal industries.

Napoleon Bonaparte was so fascinated by the order and efficiency of bees that he selected these industrious insects for use on his coat of arms, and he wore a green coronation robe decorated with golden bees when he was crowned Emperor of France. Aristotle, Cato, Varro, Pliny, and Vergil studied the bees with meticulous care, as did the greatest detective in modern fiction, Mr. Sherlock Holmes.



Alfalfa, 7 years old. Bare spot got 50 pounds an acre of potash K_2O; heavy growth got 200 pounds. Use of chemical fertilizers are rising like rocket, pages 467-474. Farmer depends on miner. ***New Jersey College of Agriculture, S. C. Stabe***

14· The Fishing Industry

1. THE NATURE AND IMPORTANCE OF FISHING

The antiquity of fishing. Hunting and fishing preceded agriculture and may be regarded as the oldest occupations of man. Prehistoric man learned to use spears, hooks and lines, rods, and nets for catching fish. These methods were used by the ancient Egyptians and Chinese, by the early Greeks, Romans, and Phoenicians, and they are used in various parts of the world at the present time.

Prehistoric man also discovered that a rotten fish is a distasteful thing. He learned to preserve fish in an edible condition by drying, smoking, freezing, and salting. These methods are still used today.

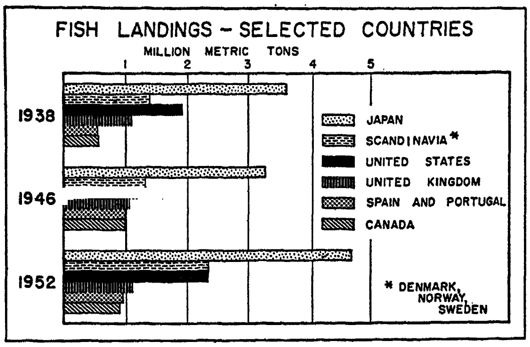
It may have been the desire for fish that first led man to sail upon the sea. All the great maritime nations have had well-developed fishing industries, including in recent centuries the Scandinavians, Portuguese, Dutch, British, French, Americans, and Japanese. In the largest room of the State House in Boston a codfish carved of wood is prominently suspended from the ceiling, a reminder of the importance of fishing ever since the first New England settlements were made.

Diverse methods of commercial fishing. The word "fishery" means the act of catching animal life from water and includes such varied activities as trapping salmon in rivers, harpooning whales at sea, diving for sponges and pearls, digging clams out of the mud, and shooting seals with rifles or killing them with clubs along a rocky seashore. Fishery also refers to the place where fish are caught, a more popular meaning that is used here.

Modern methods and equipment are almost as diverse as the species of fish. For example, purse seines, or large nets that can be closed about a school of fish, are used in mackerel, herring, and menhaden fisheries. Hand lines are the chief gear in catching bluefish, Spanish mackerel, and red snappers. Gill nets, in which the unsuspecting fish is caught by his own gills, are used in the weakfish and shad fisheries. The fighting tuna are caught one at a time by rod and line.

About three fourths of the world's fish are caught at sea. Fishing vessels vary in size from tiny sailing craft and motorboats to the huge whaling factory, a vessel of 7000 to 15,000 gross tons that is equipped with a harpoon gun to catch the whale, with powerful electric winches to haul him aboard, and with modern machinery to take him apart and prepare whale oil, fertilizer, and other products for the market. Steam and Diesel vessels account for most of the world's catch of fish, but sailing vessels remain in common use along the shores of every continent.

Most fishing craft are small, and the life of the fisherman is rigorous. The modern two-masted schooner used in the cod, haddock, and halibut fisheries of the North Atlantic is less than 125 gross tons in size. Today it has



Japan is hungry since the war losses. *U. N. Statistical Yearbook, 1953*

fewer sails and is equipped with an auxiliary gasoline or Diesel engine, a guarantee against the fickleness of the wind. It carries with it a number of rowboats, or dories. Upon arrival at the fishing grounds, two men set out in each dory carrying a trawl, a line about 3000 feet long, to which are fastened many short lines with baited hooks. The men in the dory spend the day removing fish and rebaiting hooks. This is a hard manual task. In stormy seas it is not a job for timorous men.

Mechanized fishing. With the advent of the dragger and trawler in the early years of the present century, fishing joined the ranks of mechanized industries. Trawlers vary from 300 to 500 gross tons in size, draggers being smaller craft. Most of them are propelled with Diesel engines. Each is equipped with a conical-shaped net, which is dragged along the sea bottom and scoops up thousands of cod, haddock, halibut, sole, hake, or other bottom-feeding fish. The fish are packed in ice, and the temperature of the hold is kept low by refrigerating machinery. The use of draggers and trawlers, permitting fewer men to catch more fish, has forced many fishermen and fishing schooners into idleness.[1]

As every amateur fisherman knows, the big problem is to locate the fish. This ageless problem has been partially solved for commercial fishermen by the perfection of the electronic fish-finder, which was first developed as a depth recorder for our Navy during World War II. This device, no larger than a portable radio, operates by sound waves and reveals instantly where fish are, about how many there are, how fast and in what direction they are moving, and frequently even what species. In this new era of mechanized fishing it seems that the poor fish scarcely has a chance.

An exhaustible resource. Fish are like trees. They reproduce themselves if given a chance. Unfortunately, the history of commercial fishing has been one of wanton exploitation, dwindling local supplies, and migration to new and more distant fishing grounds—a replica of the history of American lumbering. In pitifully few instances has fishing been controlled so as to assure a renewing and dependable yield of fish.

Principally because of overfishing, our North Atlantic rivers yield less than 15 million pounds of shad a year, as compared with 50 millions in 1896, while the salmon is now extinct except in a few streams in Maine. In the Pacific Northwest the salmon catch in the Columbia River is now about half of its previous size. The Pacific salmon and halibut industries are moving steadily northward. European trawlers in the North Atlantic sometimes travel 5000 miles on a single voyage, and some of them now catch cod on the fringe of the Arctic icefields.

In postwar years many an American trawler has arrived in Boston harbor only to sell its fish as fertilizer or dump it into the sea simply because the fishermen felt that the market price was too low. The shipowner gets 40% of the proceeds of the catch, and the fishermen get 60%.

Fish culture. Many centuries ago the Chinese and Japanese found out that fish growing in ponds and rivers is one of the

[1] For detailed accounts of the vessels and methods used in commercial fishing, see Alfred C. Hardy, *Seafood Ships*, Crosby Lockwood & Son, Ltd., London, 1947, and John G. Glover and William B. Cornell (eds.) *The Development of American Industries*, Prentice-Hall, Inc., New York, 1951, pp. 79–99.

easiest ways of getting meat in a densely peopled country. Oyster culture was an art among the Japanese a century before the Declaration of American Independence. There are many fish ponds in Germany and Poland. Most of the fish raised in ponds are carp, a docile fish that can be fed in a pond like poultry in a yard. In this country there are a few "fish farms" along the upper Mississippi in Iowa, Illinois, and Wisconsin that supply New York City with carp. The fish are fed upon corn, vetches, potatoes, malt, snails, slaughterhouse refuse, and many other foods. The average yield is about 100 pounds of fish per acre per year, and much higher yields are sometimes made.

The threatened extermination of many valuable species of fish has led to systematic fish culture, which has thus far been chiefly devoted to collecting the eggs, hatching them, and caring for the fry for a short time. The U. S. Fish and Wildlife Service hatches billions of fish eggs and releases the fry in streams and lakes to replenish the supply. There are several salmon hatcheries in Oregon and Washington, shad hatcheries in the eastern rivers, lobster hatcheries upon the New England coast, and hatcheries upon the Great Lakes for whitefish, lake trout, and other fresh water varieties. Many foreign governments are also aiding the fishing industry by the same means.

Most suggestive of all, perhaps, for prompt results, is the discovery, now well established, that fish meal in combination with the existing rations reduces the cost of producing beef, pork, and poultry. While we may slowly, through the generations, learn to eat semimicroscopic mollusca, the sea may be quickly patrolled with airplanes, guiding the floating factories to the masses of mollusca to be scooped up and turned into cargoes of cow feed, pig feed, and poultry feed for the indirect nutrition of humans.

Importance of the fishing industry. Although fishing is of outstanding importance in some sections of the world, it plays a rather minor role in the world's economy. Only a tiny portion of the world's people earn their living by fishing. The total value of the world's annual catch of fish is less than the value of poultry and eggs sold in the United States.

Japan has the largest fishing industry. In 1953 the Japanese catch amounted to 4.0 million metric tons, as compared with 2.5 millions in the Soviet Union, 2.4 millions in the United States (including Alaska), 1.3 millions in Norway, 1.0 millions in the United Kingdom, and nearly 1 million in Canada (including Newfoundland and Labrador). In Japan about 1½ million persons are employed in fishing, about half of them working part time. The Japanese people consume more than 60 pounds of fish per capita annually.

The American fishing industry employs about 269,000 persons and provides indirect employment, as in canning, for about 300,000 more. Our fishing fleet consists of 10,500 vessels of 5 tons or more and many smaller craft. About 4000 shore establishments are engaged in handling and preserving fish. More than one third of the annual catch is sold as fresh or frozen fish, nearly one third is canned, only 2% is cured, and the remainder is sold as by-products or bait.

In 1953 American commercial fishermen caught 4½ billion pounds of fish worth $325 million. In contrast, the value of eggs sold by our farmers exceeded $1800 million. The American people consume only 11 pounds of fish per capita annually, as compared with 352 pounds of fresh milk, 151 pounds of meat, 53 pounds of eggs, and 7½ pounds of cheese.

Distribution of chief fishing regions. The world's most productive fisheries are found in the cold and shallow waters above the continental shelves of (1) northwestern Europe, (2) northeastern North America, (3) northwestern North America, and (4) northeastern Asia. Each of these fishing regions has economic access to major markets. The waters of northwestern North America are more remote from big markets than the other fishing regions, and they were the last to be developed on a large scale.

The abundance of fish in these four regions

is due to an abundance of marine plant and animal life. In the seawater are countless billions of minute plant organisms, known as plankton, that are eaten by small animal organisms, which in turn are eaten by each other and by tiny fish. The small fish in turn are eaten by larger fish. Thus, the whole pyramid of marine animal life is based upon vegetation, mostly microscopic in size.

The abundance of marine plant and animal life is the result of a combination of causes. All plants are energy parasites of the sun, and some light, however dim, is needed for plant growth. Light easily penetrates the water, which is generally less than 100 fathoms, or 600 feet, in depth. Plant food is poured continuously into the sea by the rivers, and it is well mixed in the water by storms. Furthermore, organic matter does not decay so rapidly in these cold northern waters as in the tropics.

2. EUROPEAN FISHERIES

Northwestern Europe. The seas of northwestern Europe comprise the greatest fishing region in the world. These waters include the Barents Sea, the Norwegian fiords and shallower parts of the Norwegian Sea, the Skagerrack and Kattegat, the Baltic Sea, the gulfs of Finland and Bothnia, the North Sea, the English Channel, and the Irish Sea. The fishermen of nations adjoining these waters, excluding the Soviet Union, catch about 6 million metric tons of fish a year. Cod, herring, and haddock are the principal species, but many other kinds are caught.

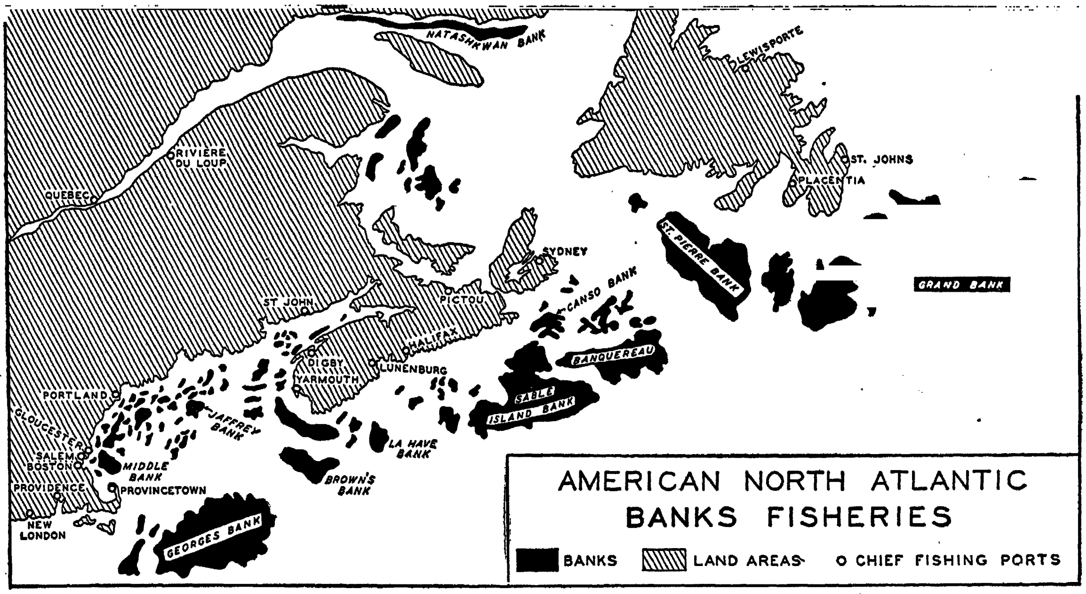
The North Sea is the most important fishing ground in the world. It is shallow and abounds in fishing banks, the Dogger Bank being the largest. The North Sea is surrounded by populous lands, being within easy reach of the British, French, Belgian, Dutch, German, Danish, Swedish, and Norwegian fishermen. It is shared by all, since by international law the sea 3 miles and more from shore belongs to all mankind. Great Britain is the undisputed leader in the North Sea fisheries. British trawlers, draggers, and other craft carry thousands of tons of fish each year to the ports of Grimsby, Hull, London, Yarmouth, Lowestoft, and Aberdeen. Grimsby is undoubtedly the world's greatest fish market.

Norway is more dependent upon fish than any other nation except Iceland. That the hardy Norse have been able to people their bleak and rocky coast all the way to the Arctic has been due largely to this harvest of the ocean. Norway's long and narrow fiords, carved by the glaciers ages ago, are excellent fishing grounds. About 115,000 Norwegians are engaged in fishing, including nearly 80,000 part-time fishermen. When the seasonal fish runs are under way, farmers, lumbermen, and others get out their boats and become fishermen for a spell. As many as 40,000 men go to the Lofoten Islands each year to fish for cod. The Norwegian catch consists chiefly of herring, cod, and coalfish, with lesser quantities of mackerel, sea trout, salmon, and lobsters. Each year Norwegian whaling vessels return from Antarctic waters with about 1 million barrels of whale oil.

No nation rivals Iceland in catch of fish per capita, which amounts to about 7000 pounds per inhabitant annually. About six sevenths of the island is unproductive. Most of the people raise sheep and hay, turnips, and a few other crops or are engaged in fishing. The fish catch consists chiefly of cod, haddock, and herring. Fish, in salted, smoked, canned, or frozen form, account for 95% of Icelandic exports.

Minor fisheries. The Bay of Biscay, the waters of northwestern Spain and Portugal, and the open sea as far as the Azores and Canaries comprise a minor fishing region where many subtropical fish are caught. The region is best known for its sardines, or sun-dried pilchards, that are packed in oil and canned. Bordeaux, France, is the leading canning center.

Hundreds of fishing villages line the shores of the Mediterranean and the Black Sea. The waters along the coasts of Spain, France, and Italy yield large numbers of sprat and sardines. Eels are caught in Italian waters.



School grounds—schools of fish and schools of fishermen. There is no record of the time that Europeans began to fish these Banks. ***C. F. Jones and G. G. Darkenwald, Economic Geography, The Macmillan Co., New York, 1954, p. 45***

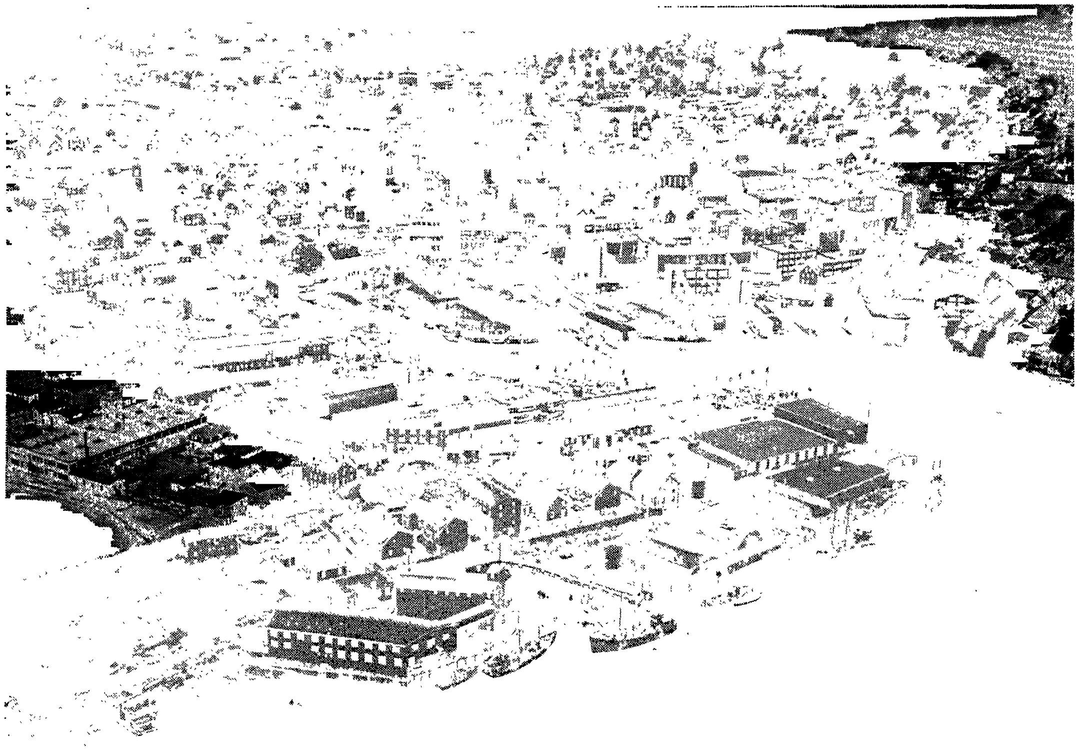
Sponge diving is important along the shores of French North Africa, the Adriatic Sea, and Greece. In southern European Russia the river fisheries and those of the Caspian Sea are famous for their sturgeon, and the roe of this fish, or caviar, is the most valuable fishery product exported from the Soviet Union.

3. ATLANTIC FISHERIES OF NORTH AMERICA

Northeastern North America. The cold waters between Cape Hatteras and Greenland comprise a second major fishing region, the waters to the north and northeast of Nantucket Island being much more important. The fisheries of this region are based on a rich combination of rivers, bays, and shallow offshore banks. The fishing banks extend along the coasts of New England and eastern Canada from Nantucket Island to Newfoundland and into the Gulf of St. Lawrence, a distance of over 1100 miles. The Grand Bank of Newfoundland is by far the largest (see Fig. 247).

The Newfoundland banks were known to the fishermen of Europe and were regularly visited before Columbus made his epochal voyage. In that day the fishing industry was relatively more important than at the present time. Practically the whole of Europe was Catholic, and even to those who could afford meat there were many fast days upon which fish must be eaten in place of meat. Scores of vessels sailed back and forth from France to these Newfoundland banks each year for a century before the French made settlements in the St. Lawrence valley. Fishing fleets from France, Great Britain, Portugal, and Italy still come to the Newfoundland banks. For more than 4½ centuries men have risked their lives fishing from schooners and dories in the Newfoundland area.

The fishing vessels that visit the Newfoundland banks today are based at home ports in Canada, the United States, and Europe. St. John's, Newfoundland, and Halifax and Lunenburg, Nova Scotia, are the chief fishing ports in eastern Canada. Most of the fish caught by the fishermen of eastern Canada are sold in fresh or frozen form on the Canadian and American markets, although about half of Newfoundland's fishery exports consist of cod that is salted, dried, and shipped to Mediterranean countries, the West Indies, and Brazil. Although cod, haddock, herring, and other species rank high in tonnage, the fish that



Gloucester, Mass., the town of fresh fish on a perfect harbor. ***Gloucester Chamber of Commerce***

commands the highest price is the much-prized lobster, which is caught in lobster pots, or baited box traps, especially on the coast of Nova Scotia.

Proximity to the banks has made fishing a leading New England industry since colonial times. Massachusetts and Maine have the most important fisheries. Most of the fish caught by our North Atlantic fishermen are landed at Gloucester, Boston, New Bedford, and Provincetown in Massachusetts, Portland, Maine, and New York City. Gloucester and Boston are the leading ports.

The revolution in fish catching has been matched by revolution in fish marketing. Not long ago Pittsburgh was about the limit to which a barrel of New England fish, with ice, could be shipped. Enter the filet, a portion of fish cut off, freed of bones, packed in cartons, frozen hard, and sent in refrigerator cars far into the continental interior. The rosefish, scorned for centuries because it has three-quarter waste, now becomes an important fish because it has two nice filets and a lot of refuse to make fish meal (stock feed and fertilizer), glue, and fish oil for casting aluminum, for lubrication, leather tanning, paint making, varnish, insect sprays, and printing ink.

Haddock and rosefish are by far the leading fish landed at our North Atlantic ports and are followed in importance by the flounder, cod, whiting, pollock, and hake. The sardines that are canned in Maine are not pilchard, but small sea herring, the same as Norwegian sardines. Maine, like Nova Scotia, has an important lobster industry.

Cape Hatteras in North Carolina is an important boundary point in our Atlantic fisheries. The waters south of the cape are much warmer because of their location and the influence of the warm Gulf Stream, which follows the general contour of the land, and these southern waters contain many subtropical fish. To the north of Cape Hatteras, a wall of cold water lies between the shore and the Gulf Stream. Cod, mackerel, sea bass, porgies, and

other northern fish are caught in these cold waters.

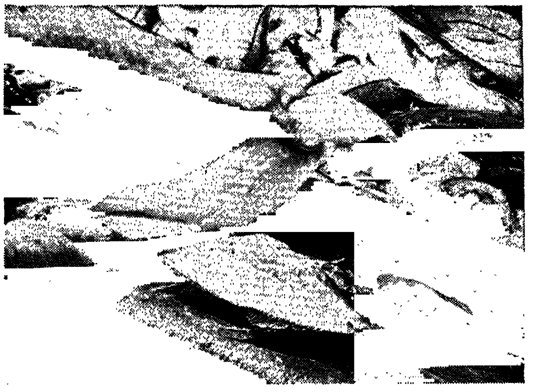
Oysters, clams, and shad. The brackish waters of the sheltered bays that are located between Cape Cod and Cape Hatteras produce some of the finest oysters in the world. The oyster, after being hatched from an egg, swims around for a time and then attaches itself to some firm substance, such as gravel or old oyster shells. For two or three years the oyster continues to grow, pumping 8 to 10 gallons of water daily through its gills and straining out the microscopic plant and animal food. When the oysters are full-grown, they are scooped up with long-handled rakes in the hands of oystermen or by large dredges. The practice of transplanting young oysters to especially prepared beds, where they will grow and receive care, is now common. Pollution, silting, and starfish are the oyster's mortal enemies.

The principal oyster-producing districts include Narragansett Bay in Rhode Island, Gardiner's Bay at the eastern end of Long Island, Chincoteague Bay of Maryland and Virginia, the North Carolina sounds, and especially Chesapeake Bay. Baltimore, Md., is the chief oyster-canning center.

The clam is a cousin of the oyster but possesses power of locomotion and is caught by being dug out of the mud. It is particularly important along the New England and Middle Atlantic coasts. Most clams and oysters are preserved by refrigeration and sold fresh. Nearly 40 million pounds of clams and about 6½ million pounds of oysters are canned in this country annually.

The shad is one of the most highly prized of American food fish. At one time it ascended the streams from Florida to the St. Lawrence in large numbers, but the total catch has declined, and the shad is now unimportant north of New York. The river herring, like the shad, is caught in Atlantic streams or in the waters near their mouths.

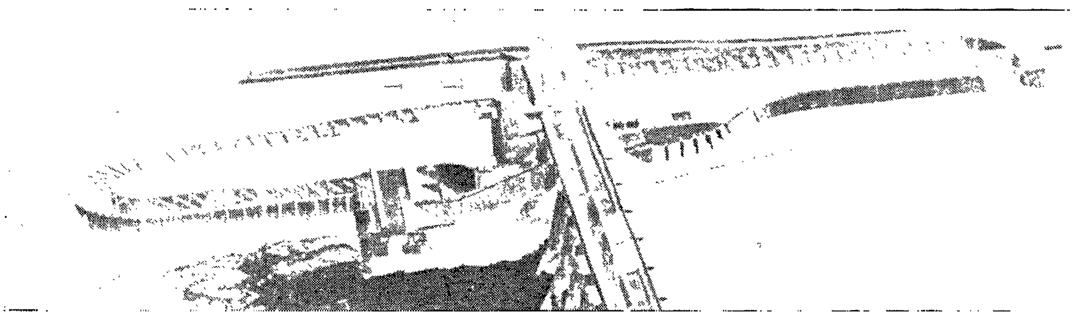
South Atlantic and Gulf fisheries. The warm-water fisheries of our South Atlantic and Gulf coasts have become more important in recent years. Red snappers, sea bass, pompano, and other fish are now widely sold in southern markets. Shrimp and oysters are very important, particularly along the coasts of Louisiana and Mississippi, with Biloxi, Miss., as the leading canning center. The shrimp fisheries of this area are the most important in the United States.



The new filet goes fresh to cactus country. Most of the fish remains for fish meal. ***General Foods***

The menhaden, a fish long considered inedible because too oily, is found in waters extending from Florida to Newfoundland. American fishermen catch more than 500,000 tons of menhaden annually, and no fish rivals the menhaden in quantity. Millions are caught in South Atlantic waters and are taken to factories along the coast where they are cooked by steam and pressed, emerging as fish meal for feeding poultry and livestock, oil for making paint, soap, and margarine, and fish scrap for the manufacture of fertilizer. A new process removes the undesirable oil, and menhaden now comes to the table as a canned fish.

The sponge of commerce is the fibrous skeleton of a marine animal whose jellylike body is washed out before the sponge is dried for shipment. Sponges are gathered by Greek divers in the shallow reefs along the west coast of Florida, the little port of Tarpon Springs being the center of the American sponge industry. The scarcity and high price of sponges has led to experimentation with sponge farming, seed sponges being fastened to weights and lowered to the sea bottom to grow.

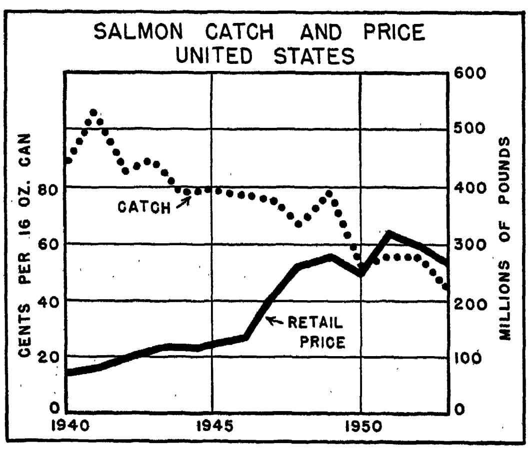


Bonneville Dam, Columbia River. Salmon enter fish ladder below dam left center. Emerge far right. A ladder at other end also. *U. S. Army Engineers*

4. PACIFIC FISHERIES OF NORTH AMERICA

Northwestern North America. The waters between northern California and the Bering Sea now rank among the world's greatest fisheries. The continental shelf in this region is much narrower than those of northwestern Europe and northeastern North America, and in some places it scarcely exists. In the Gulf of Alaska, which has rich halibut and cod fisheries, the shelf extends about 60 miles from shore, and then the depth of the water increases from 120 to 1500 fathoms (720 to 9000 feet) in a distance of 5 miles. This long and narrow fishing region is best known for its salmon and halibut, but large numbers of herring, sole, cod, and other fish are also caught.

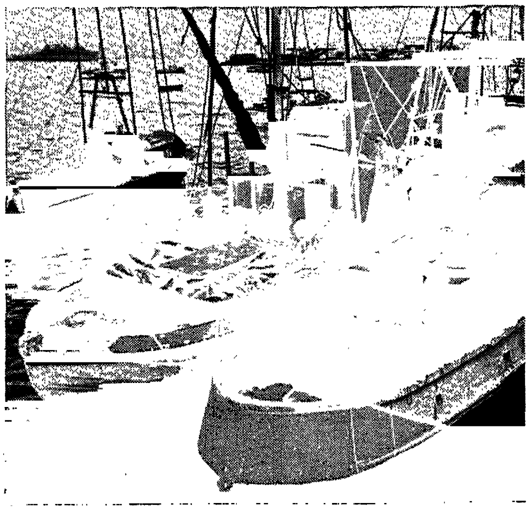
The salmon is easily the king of river-running fish. Living most of their life in the ocean, the salmon return to the fresh-water streams where they were originally hatched in order that the females may lay their eggs. Salmon are caught in the Pacific rivers as they return from sea, in waters near the mouths of the rivers, and also at sea. As a result of depletion, few streams south of the Columbia have salmon runs of commercial importance. Today the Alaskan salmon catch is about four times larger than that of our Pacific states, while that of British Columbia is 60% to 70% larger.



Is this a measure of national thrift? *Time Magazine*

The American salmon catch, including Alaska, amounts to about 250 million pounds a year, while that of British Columbia ranges between 125 and 175 million pounds. Salmon canning was first established in California, Oregon, and Washington, then in British Columbia, and finally in Alaska. As the salmon season approaches, vessels loaded with empty cans and carrying many workers leave Seattle, Vancouver, and other ports for the northern canneries. Within a few weeks the vessels return with canned salmon to their home ports. The value of the American salmon pack amounts to more than $150 million a year, or about one third of the total value of canned fishery products in the United States. Both American and Canadian canned salmon are exported to many parts of the world. As the catch declines, less will be exported.

More than half the world's halibut are caught between Cape Blanco, Oregon, and Dutch Harbor in the Aleutian Islands of Alaska. Most of them are landed at Puget Sound ports and at Prince Rupert, British Columbia. The halibut is a fish of excellent



The fishing boats of San Diego bring frozen harvests from the far Equator. ***San Diego City & County Visitors' Bureau***

5. ASIATIC FISHERIES

Northeastern Asia. The rivers, bays, and seas of northeastern Asia comprise one of the world's truly great fishing regions. Here again we find cold waters, a highly indented coastline, an abundance of edible fish, and a long-established fishing industry such as prevails in similar latitudes of North America and northwestern Europe.

As a result of World War II, the Soviet Union took control (among other things) of the Kurile Islands and all the island of Sakhalin. The waters of Sakhalin are rich in herring, sea trout, salmon, cod, and crab. The cold and rugged Kuriles are noted for their salmon, cod, and crab fisheries, their fur seal and sea otter being of minor importance. Canned crab meat was an important export to the United States in prewar years, when the Japanese owned these islands.

Salmon are abundant in the rivers and along the coast of eastern Siberia, the Amur River being an important source of supply. Apparently a northward migration of fishing is under way, similar to that of northwestern North America. In 1930 over 70% of all flounders were caught in Peter the Great Bay near Vladivostok, whereas in recent years about 80% of the flounder catch has occurred in the waters of Kamchatka and Tartar Strait much farther north.[3]

The Japanese people catch and eat more fish than any other people in the world. Two reasons account for this. One is the almost entire absence of the meat animals in Japan, and the other is the abundance of fish in the waters surrounding the country, which happens to be composed entirely of islands, thus tempting its people to go to sea.

Fishing villages line the coasts of the four main islands of Japan. Fishermen's houses are frequently just above the reach of the tide and sometimes cling to precipitous cliffs. The narrow beaches are strewn with nets and drying fish, and many small sailing craft are moored to the shore. Hokkaido, the northernmost of the main islands, has a little coal mining and a little lumbering, and some agriculture of the northern Wisconsin type but is too cold for much rice. Much of it is too rough for any other kind of agriculture. Its people, like those of Norway and Newfoundland, must depend upon fishing.

In prewar years Japanese fishermen scoured the waters of eastern Asia from Formosa to the Bering Sea, especially the waters of Korea, Sakhalin, and the Kuriles. Treaties with the Soviet Union gave the Japanese fishing rights along the entire Siberian coast. Today these fisheries are closed to the Japanese. This presents a problem for a crowded nation, as fish has always been an important item in the Japanese diet. Without Manchurian soybeans and other foreign sources of vegetable proteins, the Japanese in postwar years have been averaging 55 grams of protein per person daily, as compared with 69 grams before the war.[4]

[3] See V. Katkoff, "The Flounder Industry of the Soviet Far East," *Economic Geography*, April 1952, pp. 171–180.

[4] Nutritionists consider 70 grams of protein daily as necessary for health, and 80 grams as desirable. See Ada Espanshade, "A Program for Japanese Fisheries," *The Geographical Review*, January 1949, pp. 76–85, and Edward W. Allen, "Fishery Geography of the North Pacific Ocean," *ibid.*, October 1953, pp. 558–563.

Cold currents from the north bathe the shores of Hokkaido and northeastern Honshu and circulate in both the Sea of Okhotsk and the Japan Sea. The warm Kuroshio or Japan Current from the south bathes southeastern Japan and has a branch entering the Japan Sea. Diverse marine environments afford Japanese fishermen a great variety of fish. The catch includes pilchard (sardine), mackerel, herring, cod, pollock, bonito (skipjack), tuna, cuttlefish, shrimp, oysters, lobsters, crabs, shark, and even the octopus. Inedible fish and fish scrap are never wasted, being used for fertilizer.

Minor fisheries. With the exception of Japan, fishing plays a minor role in the economy of most Oriental countries. In 1953 the Republic of India, with a population of 367 million, had a catch of fish amounting to only 1,000,000 metric tons. Indeed, the total tonnage of fish caught by the people of India, South Korea, the Philippine Islands, British Malaya, and Indochina was less than two fifths of the Japanese catch. Prewar and postwar data are lacking for China, which has long made intensive use of the fish resources afforded by its rivers and coastal waters. Many Chinese fishing craft visit the Chusan Archipelago.

Diving for pearls is an ancient occupation that is practiced in the Persian Gulf, the Gulf of Mannar in Ceylon, the Torres Strait between New Guinea and Australia, the waters of the Moluccas and Aroe Islands, and in a few other parts of the world. Both pearls and mother-of-pearl are obtained from the shells of inedible oysters in tropic waters. The mother-of-pearl is the internal part of the shell, while the pearl is a secretion of the same matter around some foreign substance that gets inside of the shell and serves as an irritant. Some years ago the Japanese succeeded in producing "culture pearls" by providing a suitable irritant inside the shell of oysters, and these can scarcely be distinguished from the pearls formed by nature in the sea. Culture pearls are much cheaper than the pearls of the sea, but synthetic pearls are the cheapest of all.

15· Leather, Furs, and Rubber

1. THE RAW MATERIALS FOR LEATHER

The antiquity of leather making. If man has been man for 500,000 years, as some anthropologists think, when did he not modify skins to make leather? Leather is made by cleaning and treating hides and skins so that they will not rot and will remain pliable. Articles of leather more than 3000 years old and in perfect condition have been taken from the ancient tombs of Egypt. Leather making is one of the oldest industries.

The supply of hides and skins. A great variety of animals furnish hides and skins for leather making. Naturally, the domestic animals are most important—cattle, sheep, goats, horses, and pigs. Cattle and calves, sheep and lambs, and goats and kids provide about 90% of all hides and skins used in the United States, while the horse, kangaroo, deer, snake, and shark supply most of the remainder. Animals of lesser importance contributing to our leather supply include the alligator, crocodile, lizard, manatee or sea cow, monkey, ostrich, porpoise, hair seal, walrus, whale, and wolf. Indeed, the skin of man at times has been converted into excellent leather.

The term *hides* in the leather trade refers to the epidermis of large and full-grown animals, such as walrus hides, oxhides, cowhides, and horsehides. Small or immature animals yield *skins,* for example, kangaroo skins, calfskins, coltskins, sheepskins, lambskins, goatskins, and kidskins. *Kips* or *kipskins* are intermediate products, usually the skins of undersized cattle. Custom decrees that the epidermis of the hog be known as pigskin, no matter how large the hog.

The United States supply of hides and skins. The United States is a large producer of hides and skins, and about three fourths of its domestic supply comes from meat-packing plants. These packer hides are skinned, trimmed, and cured by experts; and they command a higher price than the country hides that are obtained from farmers, ranchmen, and small butchers throughout the country. Country hides are usually of irregular size and pattern and are sometimes damaged by ticks, grubs, and brand marks.

In spite of its large domestic supply, the United States must import more than 100,000 tons of hides and skins annually. Cattle hides, calfskins, and kidskins account for 40% of our imports; sheep- and lambskins, about 20%; goat- and kidskins, nearly 20%; and many other hides and skins, the remainder. Argentina and Brazil provide more than one half the imported cattle hides; European nations, about half the calfskins. New Zealand leads in sheep- and lambskins; India, in goat- and kidskins; and Australia in kangaroo and wallaby skins. Every continent and almost every country helps to supply this country with raw materials for leather.

Dried or salted hides can withstand rain, dirt, and rough handling; they can be carried

by any means; and hence they are one of the safest and most convenient commodities that can be carried over rough and difficult pack trails. Many of the world's primitive peoples ship hides and skins to markets thousands of miles away. Sheep- and goatskins in particular come from the rough, the arid, the poor, and the undeveloped countries, which cannot tan. On the other hand, hides and skins are also exported from the richest and greatest manufacturing nations in western Europe—Great Britain, Germany, and France—where the fuller utilization of resources, due to a dense population, has produced a scarcity of tanning materials. One of the many results of two world wars has been, first, shutting off of supplies and then the development of home industry. Thus, a tanning industry has sprung up in Argentina, Brazil, India, Australia, and South Africa, and consequently our imports of hides and skins have decreased about 50% since the 1920's.

Vegetable tanning materials. Tanning usually consists in treating the skin with a strong astringent, tannin, a very common vegetable substance that unites with certain elements in the hide and changes it from a material prone to decay to one of great durability. Tannin, like sugar, is widely distributed among plants and is found in workable quantities in all continents. Its usefulness in tanning seems to have been discovered independently, long ago, in many parts of the world.

Until late in the last century the peoples of Europe and America depended for tanning almost entirely upon the bark of oak and chestnut in southern, and of hemlock in northern, locations. The increasing scarcity of forests and the growing supply of hides, which world commerce produced, has created a lively trade in other tannin-producing materials, so that now no less than 50 of them are in use, but not more than 10 are important.

Tanning extracts. With the increase in distant commerce, there is a growing tendency to ship tanning materials in concentrated forms, thus lessening transportation costs. The extracts were formerly made only in tanning factories where used, but now they are to a great extent made near the centers of production. Thus, Argentina and Paraguay now ship quebracho extract and very few logs, since the extract averages 62% to 68% in tannin compared with 25% to 30% in the heartwood of the quebracho tree. Likewise, Sweden, Yugoslavia, and other European countries export oak extract instead of oak bark, because the extract has a tannin content of 30%, or about treble that of the tree bark.

Quebracho today is king of vegetable tanning materials.[1] Since 1924 quebracho has provided more than two thirds of all tannin entering into international trade. Although quebracho extract gives leather a fine color, it does not produce the best grain, and it is usually used in combination with other tanning agents. The quebracho tree grows wild in the Chaco region of northern Argentina and Paraguay and in adjoining areas of Bolivia and Brazil. Quebracho means "ax-breaker," and the hard wood is so heavy that it will not float. A single log may weigh more than 5 tons. Temporary railroads deliver logs to the extract factories, which are located along waterways. In 1953 the United States imported about 134,000 tons of quebracho extract worth $27,228,000, nearly all of it from Argentina and Paraguay.

The trade in tanbarks. Wattle extract and wattle bark, worth $4,381,000, ranked second among American imports of tanning materials in 1953. The Union of South Africa and British East Africa are by far the leading sources of supply. The black wattle tree, a member of the acacia family, was introduced from Australia into South Africa years ago. The bark may be harvested when the tree is only 10 years old and yields more than one third of its weight in tannin.

Sumac is a shrub or small tree growing wild in the Mediterranean region of Europe and

[1] See Dorothy C. Janis, "Production of Industrial Quebracho," *Economic Geography*, April 1945, pp. 145–151.

the Appalachian region of the United States. In Sicily it is cultivated for its leaves, which are regularly cut and dried like hay and shipped to the tanneries powdered and in sacks. The Sicilian sumac industry fits well into the industrial conditions of that overpopulated island. The plant grows without tillage on land too dry and rough for other crops, and it affords employment when other work fails and other crops do not need attention. Appalachia once harvested and shipped sumac for tanning but now has more lucrative employment for her workers. The Sicilian industry also is declining.

TABLE 15:1. United States Imports of Tanning Materials, 1953
(thousands of pounds)

Extracts	
Quebracho	267,984
Wattle	37,134
Hemlock, chestnut, and divi-divi	21,225
Mangrove	7,438
Valonia	2,022
Myrobalans	805
Sumac	22
Oak	9
Miscellaneous	2,998
Bark, nuts, etc.	
Wattle bark	26,557
Mangrove bark	23,984
Myrobalans fruit	21,813
Valonia nuts	14,393
Divi-divi fruit	2,013
Sumac leaves	896
Nutgalls or gall nuts	762
Quebracho wood	2

Source: International Economic Analysis Division, U. S. Bureau of Foreign Commerce, Washington.

The bark of the mangrove tree, which grows along swampy shores in many parts of the tropic world, has become an important source of tannin. The United States obtains nearly all its mangrove extract from Malaya, while the bark comes chiefly from Colombia and Mozambique. Myrobalans, the dried fruit of a leguminous tree in central India, is another important tanning material. Both mangrove and myrobalans are commonly used in tanning heavy leather for shoe soles and machinery belting.

Oak and hemlock bark and the wood of the chestnut tree have long been the major tanning materials produced in the United States. Our forests have steadily dwindled in size, and a blight has now practically exterminated the American chestnut trees. The United States supplies only 30% of its needs for tanning materials.[2] We are vitally dependent upon imports (see Table 15:1).

Tanning materials of lesser importance. Such are the dried pods of the divi-divi tree that thrives in the lowlands of Caribbean America, the nutgalls of the Near East, the leaves of the gambier shrub of Malaya and Indonesia, and the roots of the common palmetto palm found in many tropic and subtropic lands. Valonia, a rich tanning material, is nothing more than the acorn cups of the valonia oak (also called Turkish oak) picked up by women and children in the forests of Turkey and Greece. Turkey is the major source of supply, most of which moves through the port of Smyrna en route to the markets of western Europe and the United States.

Tanning processes. Hides are preserved in salt when they arrive at the tanneries. To prepare them for tanning, both salt and dirt are removed with cold water, hair is removed by the use of lime, the hides are then washed and dried, and surplus flesh is cut off by machines.

When vegetable tanning materials are used, the hides are soaked in tanning liquor for about 15 days. Then they are placed in large lay-away vats, each hide being sprinkled with powdered tanbark, and the vats are filled with tanning liquor. The solution is changed from time to time, and by the end of 2 to 6 months the tanning has converted the hides into good leather. Most of the leather for shoe soles, upholstery, belting, and luggage is produced with vegetable tanning agents.

The chrome process of tanning was developed in the 1880's, and it uses chromite as its basic material. Production of this mineral is negligible in the United States, and we im-

[2] Edward L. Allen, *Economics of American Manufacturing,* Henry Holt & Co., New York, 1952, p. 436.

port our supply from the Union of South Africa, Turkey, the Philippines, Southern Rhodesia, Guatemala, New Caledonia, and other lands. With the chrome process, hides are first pickled in acid and salt and are then agitated in a solution of chromium sulfate, after which they are neutralized with an alkali. This chemical process never requires more than 6 hours. It is used in producing light leather, which is needed in making uppers and linings for shoes, gloves, jackets, and other things. Approximately one half of all leather made in this country is chrome tanned.[3]

The U. S. tanning industry. The Census of 1850 reported 6686 tanning establishments employing 25,595 people. Tanneries were small affairs like the little country grist mills and were scattered throughout eastern United States in or near the forests. Since then, tanneries have declined in numbers but have increased in size. The little tannery has followed the grist mill into oblivion, and many an Appalachian county that once had 5 or 10 tanneries now has none.

Today there are less than 600 tanneries in the United States. The larger ones are owned by the big shoe companies that produce leather for their own use and by the big meat-packing companies that tan hides and skins obtained from animals slaughtered in their own plants. In 1952 the tanneries of this country employed about 44,000 persons, paid $163,700,000 in wages and salaries, and added $285,500,000 to the value of their raw materials by manufacture.[4]

About two thirds of our tanneries are located in the Middle Atlantic and New England states. Pennsylvania leads the nation in tanning, and Philadelphia, the original home of the chrome-tanning process, is a major leather-making center. Massachusetts ranks first among the New England states. Tanneries in this section of the country have the advantages of nearness to domestic supplies of tanbark, easier access to imported supplies of hides and skins and tanning materials, and proximity to large leather-using industries. Nearly 20% of our tanneries are located in the Great Lakes region, particularly in Wisconsin and Illinois. These tanneries obtain their hides and skins from nearby meat-packing plants; they secure tanbark from the Upper Lake states; and they serve a rapidly growing market.

There are many processes between the raw hide and your shoe. Automatic shaving machine gives uniform thickness. ***Tanners Council of America***

Leather making in Europe. Tanning requires much manual labor, and the quality of leather depends largely upon the skill of management, technicians, and workers. This fact goes far to explain the importance of leather making and the quality of the product in the densely populated, industrialized regions of western Europe. Great Britain, West Germany, France, and the Soviet Union are the leading producers of leather in Europe. All except the Soviet Union are large importers of hides and skins and tanning materials.

[3] For detailed accounts of American tanning and leather products industries, see *ibid.*, pp. 422–442; Evan B. Alderfer and Harold E. Michl, *Economics of American Industry*, McGraw-Hill Book Co., New York, 1950, pp. 465–495; and John B. Glover and William B. Cornell (eds.), *The Development of American Industries*, Prentice-Hall, Inc., New York, 1951, pp. 175–199.

[4] "Tanning and Leather Products," *Industrial Marketing*, June 25, 1954, p. 495.

Great Britain imports more than 100,000 tons of hides and skins a year, and her tanning industry is concentrated chiefly around the ports of Liverpool, London, Hull, Southampton, and Bristol. London is the chief port of entry for sheep- and lambskins, while Liverpool receives over half of all hides shipped to Great Britain. More than one fourth of the nation's tanneries are located in Lancashire and Cheshire near Liverpool, the town of Merseyside ranking first among all hide-tanning centers.[5]

West Germany imports 60 to 80 thousand tons of hides and skins a year to help supply its tanneries, most of which are located in the vicinity of Hamburg, Kiel, Stuttgart, and Mannheim. Colored leather, utilizing coal-tar dyes, has long been a German specialty. In prewar years Germany ranked second only to the United States in the importation of hides and skins and the production of leather.

Leather making in France is widely distributed, Strasbourg being the leading tanning center. The position of Paris in the world of style has long enabled France to lead all nations in the export of gloves, which are made at Grenoble from leather that has been tanned with the bark of willow trees. Belgium and Italy also have long-established leather industries, the famous Florentine leather of Italy being a product of skill that dates back to the Middle Ages.

For many years the Russians employed crude tanning methods, sprinkling hides and skins with tanbark and soaking them in pits filled with water. A few high-quality leathers were produced, such as the birch-tanned leather of Kazan. Today the Soviet Union has many modern tanneries, widely distributed from Leningrad and Odessa in the west to Vladivostok on the Pacific coast.

2. LEATHER MANUFACTURES

The old and new systems of shoemaking. During the first half of the nineteenth century the shoemaker, with his kit upon his back, was an annual visitor to thousands of households in the eastern United States where one or two tanned hides awaited his coming to be converted into the family shoe supply for the ensuing year. The wandering shoemaker competed with the local shoemaker, who had his shop beside the country store and had his regular customers as the physician had his patients.

In the last quarter of the nineteenth century the old order gave way to the modern shoe factory, which began to roll out shoes through the aid of very complex machinery and a minute division of labor in which dozens, sometimes scores, of persons worked on each shoe. This division of labor and factory manufacture gave the industrial center an advantage over the skilled shoemaker and has caused his almost entire disappearance, despite the superior wearing quality of his product.

Location and size of the American shoe industry. The passing of the roadside shop was followed by a surprising concentration of manufacture. New England, with her lack of natural resources but abundant labor supply, was the first to produce shoes with modern machinery on a large scale. In the late 1890's Massachusetts alone accounted for nearly 60% of the nation's shoe output, and for some time more than one half of all shoes were manufactured in New England. The industry is centered in Brockton, Lynn, Haverhill, and Boston. Manchester, N. H., and Auburn, Maine, are really a part of the same shoe-producing region, which sends shoes to every state in the Union.

Today New England produces about one third of the nation's shoes. Massachusetts accounts for less than 20% of the total output and is followed by Missouri, New York, Illinois, and New Hampshire. The Brockton-Lynn-Boston area remains the leading shoemaking district, but St. Louis and New York are challenging its leadership. The shoe industry is well established in the Binghamton-Endicott-Johnson City district of southern

[5] See Wilfred Smith, *An Economic Geography of Great Britain*, E. P. Dutton & Co., New York, 1949, pp. 514–541.

New York, in Columbus, Cincinnati, Chicago, Milwaukee, Los Angeles, and many other centers. The early establishment of labor unions in New England, the desire of manufacturers to save transportation charges on shoes, and other forces have caused the shoe industry to spread.[6]

About 85% of all leather in the United States is used in the manufacture and repair of footwear, the remainder being used in machinery belting, luggage, upholstery, garments, gloves, harnesses and saddles, and a host of other things. In 1953 our shoe factories produced 501 million pairs of shoes, about 40% being made with rubber and composition soles. About 230,000 persons are engaged in the manufacture of leather footwear.

The American public spends nearly $3.5 billion a year on shoes. Per-capita consumption amounts to over 3 pairs a year. The ladies, with an eye on style and adornment, buy more shoes than the men. Shoe production booms in time of war, when men in uniform walk more miles per day than they ever did as civilians.

American glove manufacture. A surprising concentration of leather manufacture occurs in our glovemaking industry. More than one half of all leather gloves, and about 70% of all dress gloves, manufactured in the United States are produced in the cities of Gloversville and Johnstown, in Fulton County, N. Y. The combined population of these cities is less than 40,000. There appears to be no reason for this other than historical accident. Many years ago some members of a Scottish glovemakers' guild settled here and began to make gloves out of deerskin. The house and village industry was handed down from generation to generation until the sewing machine and the factory made it possible for these cities that had the start to maintain the leadership in glovemaking, for which they have no natural advantage over a thousand other towns.

Leather manufacture in foreign lands. Primitive tanning and leather manufacture is carried on by the natives of every continent, as it has been for centuries. Some leather is produced and manufactured in almost every country. Shoemaking remains a household and workshop industry in large sections of the Orient and other parts of the world.

The great industrial nations of Europe have large and modern shoe factories like those in the United States. The Bata plant at Zlin, Czechoslovakia, is one of the world's largest, with a daily output of 200,000 pairs and a large export trade prior to World War II. In foreign lands, as in this country, the principal development of shoe factories has occurred in the largest market areas.

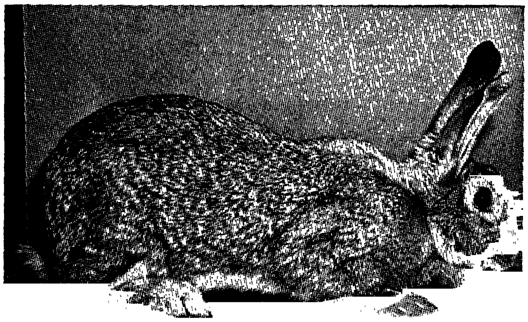
The rise of tariffs after World War I stimulated modern leather manufacturing in many lands. Shoe factories are well established in Canada, South Africa, Australia, New Zealand, Japan, India, and many Latin American countries, especially Argentina, Brazil, Chile, Uruguay, and Mexico. As a consequence, the export of shoes from western Europe and the United States has declined.

In the Orient many city people, especially the richer classes, wear factory-made shoes, while the poverty-stricken masses continue to wear leatherless footgear of straw, cotton, and wood, or none at all. The world has many millions of people who cannot afford leather shoes. Footwear is by no means a necessity in the tropics, and the homemade sandal may be far more comfortable than the modern shoe. The typical American boy who goes barefooted in summer experiences one of life's big thrills.

3. FURS

The supply of furs. Furs are a branch of the leather trade that had a tendency to go down rather than up as the population of the

[6] The formation of the United Shoe Machinery Corp. in 1899 contributed to decentralization. This firm, with headquarters in Boston and a plant at Beverly, now makes about 95% of the nation's shoemaking machines, which are leased to shoe manufacturers in this country and in many foreign lands. All shoe manufacturers pay the same fee per unit of output for use of the machines. This leasing system has enabled many small shoe factories to get started and remain in business with a low capital investment. See Alderfer and Michl, *op. cit.*, pp. 485–488.



Rabbit, game: in Europe a crop; in Australia a terrible pest. As fur, rarely himself, enough aliases to be a whole menagerie. ***U. S. Department of Agriculture***

world increased. This was because nearly all the furs were, until recently, taken from wild animals, many of which are carnivorous. As a further limiting factor, many of them live in forests, and the forests are being cut and burned. Thus the woods of our two northern forest belts are the chief home supply of furs, but the chief part of some of the rarer product comes from the great subarctic forest that practically girdles the world from southern Alaska to Labrador and from Norway to Kamchatka. Throughout this vast and frosty region the wandering trapper annually makes deep journeys into the wild forest and emerges at the end of weeks or months with a bale of fox, muskrat, mink, martin, beaver, otter, sable, and other skins.[7]

New York and St. Louis are the chief fur markets of America, receiving thousands of bales of furs from all over the world, which are sold annually at fur auctions. In like manner, Leipzig was for many years the most important fur center of Europe, but London surpassed it in the 1930's.

Development of fur farms. In recent decades fur farming has become established in Canada and the United States in response to a keen and normally increasing, but fluctuating, demand. Starting in Prince Edward Island this suggestive new industry has become established throughout Canada. Fur farms in this country are especially important in southwestern Wisconsin, a silver fox center, and in northern Wisconsin, the Upper Peninsula of Michigan, Manitoulin Island in Lake Huron, and the Adirondak Mountains of New York.

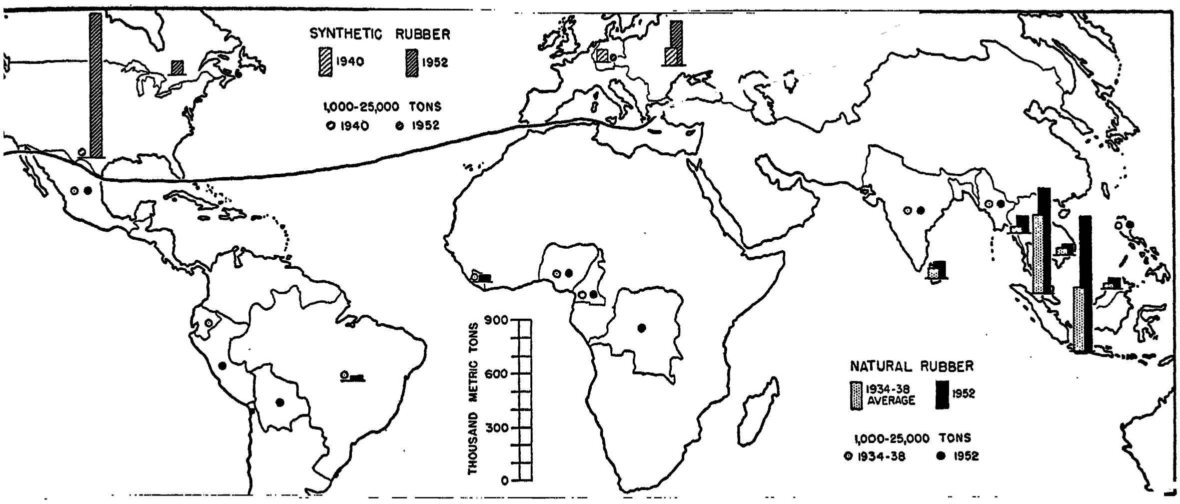
The enormous prices paid for the furs of the black fox have caused millions of dollars to be invested in fox farming, and several thousand dollars have often been paid for a single fine breeding fox. *All* the silver fox pelts, and half the mink, come from farms.

In time we may expect to see furs from wild animals superseded almost entirely by furs from animals raised in captivity, just as wild rubber and wild quinine have given way to the cultivated crop. Already, fur farming has a busy output of literature and advertising, and the high prices are stimulating a fury of experimentation with fox, skunk, muskrat, opossum, mink and others. But changing style is a deadly menace. Stocks on Wall Street never fell so far as the price of silver fox skins.

4. CRUDE RUBBER

Early developments. Columbus took back to Europe the report of a strange substance derived from the sap of a tree and which the natives used for balls and ornaments. Later explorers found it in use among the native Americans as a crude waterproofing for clothing. It was not until the last half of the eighteenth century that an English chemist found that it would erase pencil marks; hence the name "rubber." For 80 years it was used only as an eraser, for which small quantities sufficed. In 1823 a Scotsman, named MacIntosh, used caoutchouc or rubber to waterproof cloth (which yet bears his name), but in hot weather the gum became sticky, and in cold weather it grew brittle and broke. In 1842, Charles Goodyear, an American, discovered that the process of vulcanizing, or mixing

[7] The Hudson's Bay Co. buys furs from about 15,000 Indian trappers, but its 6 large department stores and 15 smaller stores in various parts of Canada are now a larger asset. "Fur Game," *Time,* August 11, 1947, p. 41.



Rubber production. Compare graph, p. 264. Plantations have hard sledding west of Suez and coolies; synthetic a major source since World War II. *U. N. Statistical Yearbook except for U.S.S.R.*

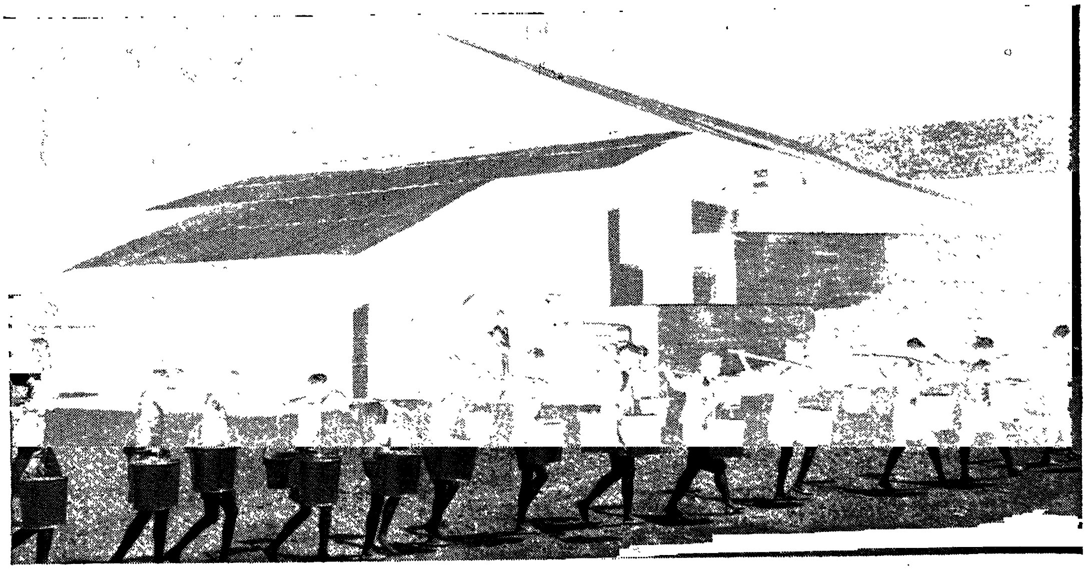
rubber with sulfur, remedied these faults, and gave it the qualities so suitable for waterproof clothing, shoes, and boots. His invention started the rubber boot and shoe industry, which has for half a century supplied what was considered at first a luxury for the well-to-do, but is now the common clothing of the ditch digger, farm laborer, miner, and lumberjack.

About the year 1890 rubber consumption entered upon a period of increase due to the invention of the pneumatic tire. The sudden development of the bicycle industry promptly followed because of the essential service of rubber. A few years later came the automobile with its still larger demand for rubber in heavy tires. The beginning of large-scale production of automobiles about 1910 caused the rubber industry to expand in like proportion, and raw rubber became one of the staple raw materials of commerce (see Fig. 264).

Wild rubber. Prior to 1913 rubber was obtained from the wild rubber trees found chiefly in the upper valley of the Amazon River. This rubber-yielding forest includes about half of Brazil and those large parts of Bolivia, Peru, and Ecuador which lie east of the Andes and receive the heavy rains brought by the trade winds from the Atlantic. Colombia also has a part of her territory in this basin. A continuous forest stretches throughout the length and breadth of this enormous valley from Pará to the Andes, and reaching beyond it into Venezuela and Guiana on the north and Paraguay on the south. Through this forest man must often fight his way with knife and ax. Scattered here and there in this gloomy jungle are trees from which the natives gather the rubber to ship down the Amazon.

Rubber hunters ascend the river in boats, and after locating a hundred or more trees and cutting paths to them through the dense tropical jungle, tap them for the latex, or rubber milk, which is laboriously coagulated on paddles by smoking it over wood fires in the forest. A paddle that has been dipped in the thick sap is held over the flames, and the acetic acid and creosote of the smoke cause the juice to harden into crude rubber. The process is repeated until a lump of rubber about the size of a man's head is formed on the paddle. It is then ready for shipment to market. The rubber is exported from the port of Manáos, which lies 1000 miles upstream and has direct liner service to New York, and from the seaport of Belém (Pará) near the mouth of the river.

In 1908–12 the Amazon Basin had a great rubber boom, prices averaging over $1 a pound. In 1910 the price of Pará rubber remained over $2 a pound, and for a few weeks it sold for over $3. Fabulous profits were



The Liberian latex carriers bring in the harvest. ***Firestone Tire and Rubber Co.***

made by rubber traders. Manáos and Pará reeked with prosperity. Steamers brought in gold watches, diamond rings, grand pianos, champagne, and other luxuries, and they carried away *bolachas,* or balls of crude rubber. Manáos improved its port facilities at a cost of $40 million. It briefly acquired culture by building a $5-million opera house, which was promptly closed when half of the first opera company died of yellow fever. In 1913 the boom collapsed, rubber selling for about 80¢ a pound, the result of competition from the Far East.

Plantation rubber production in the Far East. In 1876 Henry A. Wickham, an Englishman, carried some rubber seedlings from Brazil to England, where they were planted in the Royal Botanical Gardens at Kew, near London. In 1881 seedlings from the Kew gardens were planted in India and Ceylon, and later in Malaya and Indonesia (Dutch East Indies). The Brazilian rubber tree, or *hevea brasiliensis,* thrived in its new home, where rainfall averages about 80 to 120 inches a year and where 70° to 90° temperatures prevail, much like the Amazon Basin (see colored map at front of book).

The transplanting experiment resulted in the development of many large rubber plantations, financed by British and Dutch capital and worked chiefly by Chinese coolie labor. In 1900 practically all the world's rubber came from the Amazon Basin, but by 1914 the Far East accounted for about 60%. In 1939 the Far East produced 96½% of all rubber, most of which was grown in Malaya, Indonesia, Ceylon, Indochina, and Thailand[8] (see Fig. 261).

The plantation method of collecting the latex is fundamentally the same as in Amazonia. The plantation laborer starts out before dawn in order to complete his work before the heavy midday rains. Passing down a row of trees he makes a light gash with his knife and puts a cup underneath to catch the liquid. Later he returns to collect the latex in large pails and carry it to the plantation factory.

The preparation of rubber for shipping takes place on the plantation and is part of the work of the laborer. The latex is mixed with acetic acid and allowed to stand until it coagulates. The spongy substance resulting from this process is then washed and hung up in sheds to dry, or put into artificially

[8] Malaya and Indonesia together produced about 75% of the world's supply. Rubber, like coffee and tea, was subject to various control schemes. See Klaus E. Knorr, *World Rubber and Its Regulation,* Stanford University Press, Stanford, Calif., 1945.

heated ovens in places where the climate is too moist to dry it naturally. Sheets of rubber are pressed into small bales for shipment.

The slow drying process is often combined with smoke-curing similar to that practiced by the natives on the Amazon. This smoked rubber commands a better price, since in the smoking process the rubber is strengthened and preserved by the creosote and other substances in the palm leaves used. It goes to market as "ribbed smoked sheets."

Plantation advantages. The plantation system has many advantages over rubber gathering in the Amazon rain forest. All the Far Eastern plantations lie near the sea. The trees are set out in rows about 12 feet apart, and one worker can tap about 400 trees a day, or about five times more than the man in Amazonia, where a rubber tree is surrounded by many other species. Budding, grafting, elimination of poor trees, and continuous botanical research have resulted in yields of 1200 to 2000 pounds of latex per acre annually, or at least six times Amazon yields. Trees in the Far East are given rest periods, and supervised tapping avoids damage by deep cutting, with the result that trees live longer and produce more. Because of greater care in coagulating latex and curing rubber, Far Eastern rubber seldom has 2% of impurities, while Amazon rubber may contain as much as 25%.

The upper Amazon Basin has less than 2 persons per square mile, and the great advantage of the Far Eastern plantation system is its abundant and cheap labor supply. In most countries the contract labor system prevails. The Chinese, Hindu, or Malayan worker signs a three-year contract, specifying the kind of work, the wage rate, and usually nine hours of labor per day. Prewar wages varied from 15¢ to 60¢ a day. Although plantations have been established in Liberia, Central America, and elsewhere, they are of distinctly minor importance.[9]

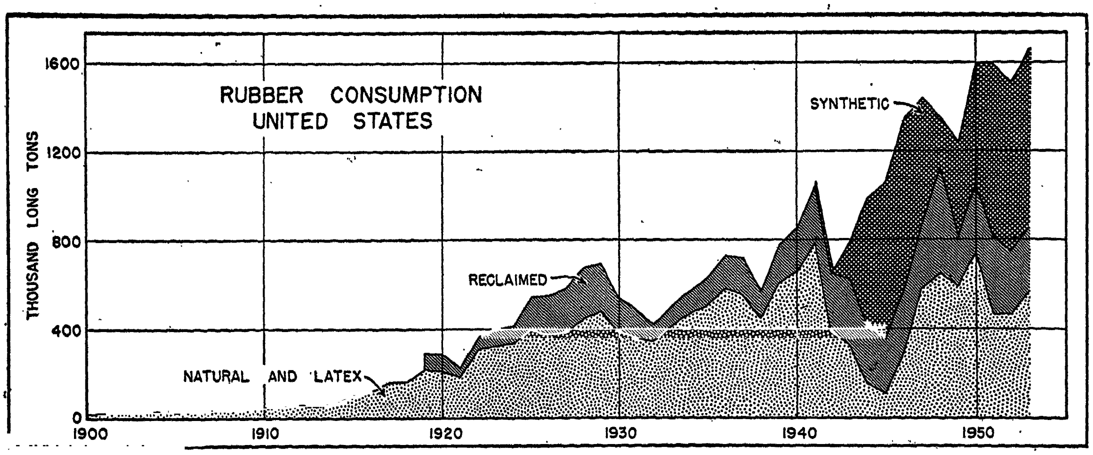
Production of native rubber in the Far East. By no means all rubber in the Far East is grown on big plantations. Nearly one half of all rubber in Indonesia and about one third of the rubber of Malaya was produced on the small farms of natives in prewar years, and native rubber accounts for nearly 60% of the Asiatic output today. Costs of production on native farms are very low. The family provides the labor, and capital investment is almost zero. Rubber on the small farms is merely a side line that brings in some cash, the native devoting most of his land to food crops.

Other sources of natural rubber. Although improved varieties of the *hevea brasiliensis* in southeastern Asia remain the one big source of natural rubber, other sources afford interesting possibilities. An inferior rubber is derived from a tree, the *castilloa elastica,* that thrives in Caribbean America. Ceará rubber is obtained from a tree, *manihot glaziovii,* found in northeastern Brazil. A species of fig, *ficus elastica,* in northern India yields a product known as Assam rubber. The late Thomas Edison tried to obtain rubber from milkweed and goldenrod but without success.

The guayule shrub yields about 10% of its weight in rubber. It thrives in the semiarid climate of northern Mexico and southern Texas. The shrub is rooted up and taken to factories at Torreón and Saltillo, where it is chopped up and the gum is dissolved, yielding rubber. Mexican guayule rubber production reached an all-time peak of 10,800 metric tons in 1945 under the stimulus of wartime demands. In 1952 production amounted to less than 2000 tons, a tiny portion of the world's output of 1,815,000 tons of natural rubber.

Scrap piles yield a rather bountiful harvest of rubber. In 1952, 341,000 metric tons of reclaimed rubber were produced in the United States, Great Britain, West Germany, Australia, and Canada, about 80% being pro-

[9] In 1947 the Ford Motor Co. abandoned its attempt to operate rubber plantations in Brazil. For details of the Ford experiment, see Joseph A. Russell, "Fordlandia and Belterra, Rubber Plantations on the Tapajoz River, Brazil," *Economic Geography,* April 1942, pp. 125–145.



World War I, natural rubber; II, synthetic. ***Rubber Manufacturers Association***

duced in this country.[10] Our big tire manufacturers operate reclaiming plants that grind, wash, and chemically treat scrap rubber. Since reclaimed rubber does not have much resiliency, it is generally used in combination with new rubber in the manufacture of rubber products.

Synthetic rubber. Although the Germans produced some low-grade synthetic rubber during World War I, the present synthetic rubber industry is distinctly a product of World War II. Between 1939 and 1943 Germany's synthetic rubber production increased from 22 to 103 thousand metric tons, an all-time peak for that country. We entered the war on December 7, 1941, and in 1942 Malaya and Indonesia fell to the Japanese, cutting off 90% of our natural rubber supply. During the war our government spent $700 million to construct 44 synthetic rubber plants, which were operated by private industry. Our output increased from a meager 23,000 metric tons in 1942 to 236,000 in 1943, 776,000 in 1944, and 834,000 in 1945. This was a triumph of modern chemistry.

Four types of rubber are being made in this country. In 1953 GR-S (Government Rubber-Styrene) accounted for 80% of our total output. GR-S is a general-purpose product closely resembling natural rubber and can be mixed readily with it. Most of it is used in tires. Butyl is ideal for inner tubes, as it holds air ten times better than natural rubber. Neoprene is a preferred material in electrical insulation and is used in products requiring resistance to chemicals, oils, gasoline, fire, and sunlight. Buna-N has resistance to abrasion, heat, age, and oil.

The main ingredients in making GR-S are butadiene, a gas derived from petroleum, and styrene, a liquid obtained from coal. Styrene makes rubber more elastic and wear longer. Butadiene, styrene, soapy water, and a catalyst are stirred and heated in a mixing tank for 16 hours, resulting in the production of synthetic latex. The latex is coagulated in a solution of salt and sulfuric acid, crumbs of rubber forming at the bottom of the coagulating tank. The rubber crumbs resemble gray popcorn. They are dried at a temperature of 215°F., turning into brown lumps that are pressed into bales of crude rubber. A variation of this process, using the same materials at a temperature of 41°F., produces "cold rubber" that gives automobile tires much better mileage.

Petroleum, coal, natural gas, and industrial alcohol are the chief primary materials used in making most synthetic rubber. Butadiene can be obtained from petroleum or industrial alcohol, but at present the former is cheaper. More than 60% of our plant capacity for

[10] It is estimated that these five countries have 80% of the world's rubber-reclaiming capacity. U. N. *Statistical Yearbook, 1953,* p. 211.

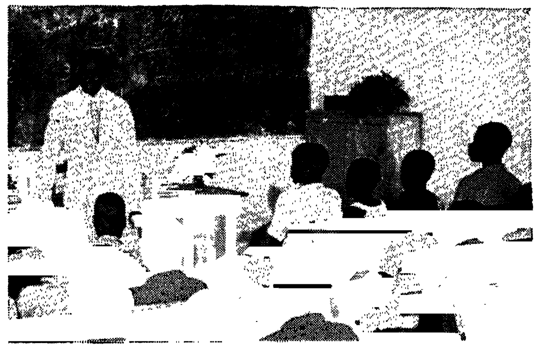
making GR-S is located in Texas, Louisiana, and southern California, near the petroleum supply. Two plants are in Akron, Ohio, the great rubber-manufacturing center; two are in Louisville, Ky., famous for its alcohol. There are only two butyl plants, one at Baytown, Tex., and the other at Baton Rouge, La.

The United States leads the world in synthetic rubber production, far surpassing the Soviet Union, Canada, and West Germany. Great Britain, with a large investment in natural rubber plantations in the Far East, has made no attempt to develop the synthetic rubber industry. The United States is by far the leading consumer of rubber. Of 1,618,000 short tons of rubber consumed in this country in 1953, 49% was synthetic, 34% was natural, and 17% was reclaimed[11] (see Fig. 264).

Synthetic rubber has come to stay. It easily competes with natural rubber in price. The migration of rubber production from the Amazon rain forest to the plantations and little farms of the Far East and lastly into the synthetic rubber factory is truly one of the great industrial migrations of modern times.

5. THE MANUFACTURE OF RUBBER

The usefulness of rubber. The art of rubber making has progressed far since the inventions of MacIntosh (1823) and Goodyear (1842) made possible the first waterproof clothing, shoes, and boots, and modern factories now unite with laboratory skill to give us an ever-increasing number of useful articles. We encounter rubber in the kitchen, in the bathroom, in the hospital, on the train. We wear it on our heads and on our heels and cover ourselves with it in stormy weather. A single concern manufactures 30,000 commodities into which rubber enters, while the inventor is constantly discovering new uses. Without rubber tires, the Western World would lose much of its mobility.



Rubber company keeps a school for Liberian employees. *Firestone Co.*

Processes of manufacture. Although the chemist and the machinist now cooperate to turn out such a huge variety of rubber articles, the fundamental process of rubber-making still remains practically the same as in Goodyear's day. Raw rubber is mixed with sulfur and then heated to bring about the chemical change known as vulcanization. From 2% to 10% of sulfur is added to make soft rubber, while over 33% sulfur may be added to make the hard rubber used for combs and fountain pens. Certain manufactures, such as the automobile tire and rubber hose, also use a reinforcement of cotton, rayon, or nylon fabric. About two thirds of all rubber in this country is used in the manufacture of tires, inner tubes, and tire-repair materials.

In the process of manufacture, crude rubber is first torn into shreds. Then the chemist goes to work making compounds with qualities to suit the eventual use of the product. Finally, crude rubber is shaped by a variety of general-purpose and specialized machines. Rubber products may be dipped, coated, molded, extruded, calendered, cast, or lathe-cut.[12]

Corporate control and location of the United States industry. Goodyear, Firestone, United States Rubber, and Goodrich are the giants of the American rubber indus-

[11] Consumption in thousands of short tons: imported dry natural rubber, 486; imported latex, 67; imported synthetic, 13; domestic synthetic, 769; reclaimed, 283. "Tires and Rubber," *Industrial Marketing,* June 25, 1954, p. 506.

[12] For details of the American rubber industry, see Allen, *op. cit.,* pp. 182–211, and Alderfer and Michl, *op. cit.,* pp. 303–323.

TABLE 15:2. Industrial Consumption of Rubber in Selected Countries, 1952
(thousands of metric tons)

Country	Natural	Synthetic	Total
United States	461	820	1281
United Kingdom	200	5	205
France	120	11	131
Germany, West	95	10	105
Japan	69	0	69
Canada	34	34	68
Italy	44	6	50
Australia	29	[a]	29
Brazil	28	[a]	28
India	21	0	21
Sweden	20	[a]	20
Union of South Africa	19	1	20
Belgium	16	2	18
World total[b]	1350	900	2250

[a] Less than 600 metric tons.
[b] Excluding the U. S. S. R.
Source: Adapted from U. N., *Statistical Yearbook, 1953,* New York, 1953, Table 130, p. 281.

try. The Big Four own about two thirds of all domestic assets of the industry, and they account for over 75% of the nation's output of tires, tubes, and rubber footwear.[13]

Rubber manufacturing occurs in 39 states. Ohio is the leader, followed by Indiana, Illinois, Pennsylvania, New Jersey, New York, Connecticut, Massachusetts, and California. Akron, Ohio, is the world's largest rubber-manufacturing center, largely the result of historical accident and the impetus of an early start.

Rubber manufacture abroad. Although the manufacture of rubber is well established in the Soviet Union, the United Kingdom, France, West Germany, and elsewhere, no nation rivals the United States in the industrial consumption of rubber (see Table 15:2). Furthermore, no nation makes such large use of synthetic rubber.

Rubber factories in Great Britain are located at Fort Dunlop, Liverpool, Manchester, Leicester, London, and elsewhere. The Dunlop Rubber Co. is an industrial giant ranking along with the Big Four in the United States. The German rubber-manufacturing industry is concentrated in the vicinity of Hanover, Berlin, Duisburg, and Halle, while the French industry is centered chiefly at Clermont-Ferrand and in the Paris area. The French firm of Michelin is a keen competitor of Britain's Dunlop and the American rubber companies in many markets overseas. It is known that the Soviet Union has developed synthetic rubber production intensively. Yaroslav has become the Russian Akron, although much rubber is manufactured in the Moscow and Leningrad areas.

[13] Allen, *op. cit.*, p. 191.

16· The Fundamentals of Manufacture

1. THE NATURE OF MANUFACTURING

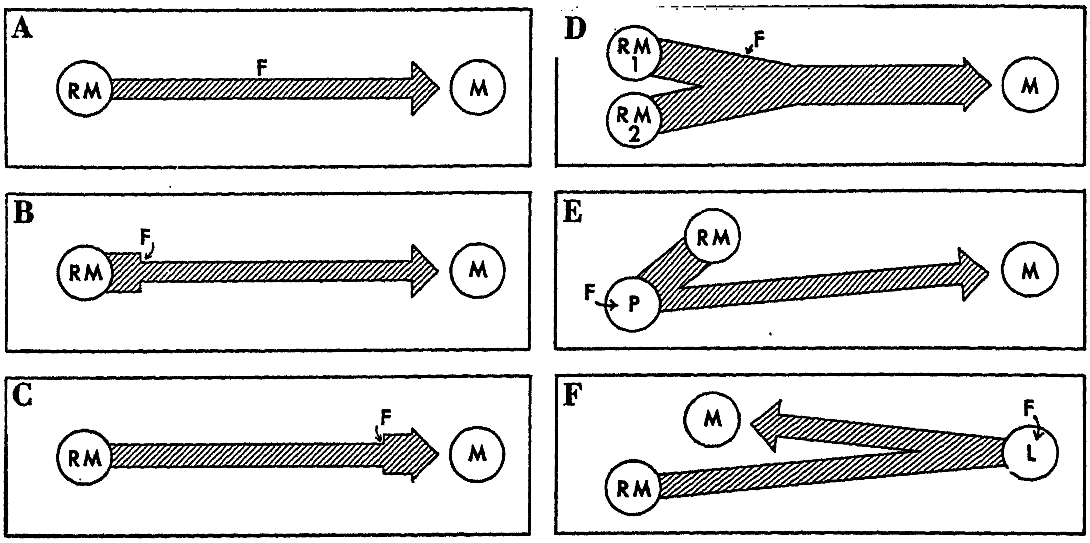
The diversity and distribution of manufacturing. An elementary fact about manufacturing is that wherever there are people there is manufacturing in some form. Prehistoric man chipped a stone, fastened it to a handle, and manufactured an ax. From earliest times the need of food, clothing, shelter, and tools has caused man to change the form of things to make them more suitable for his use. This creation of form utility is the essence of all manufacturing. In its simpler aspects, manufacturing is a universal human activity.

In the world of today manufacturing varies from the extremely simple to the highly complex. It may occur in a city skyscraper, in a sprawling plant in the suburbs, in a workshop at a village crossroad, in the tiny home of an Oriental peasant, or at some isolated site carved in the wilderness. It may involve corporate, governmental, or individual enterprise. Manufacturing may be mechanized or unmechanized, and it may be performed with or without inanimate energy. It may be conducted on a large or small scale, and it may require much or little capital, labor, and skill. The products of manufacture are legion, and their markets may be local, regional, national, or world-wide.

A second elementary fact about manufacturing is its geographic concentration. The infinite variety of types and locations has not led to an even distribution of manufacturing activity over the face of the earth. Major concentrations of modern manufacturing have developed and flourished in a limited number of places comprising less than 10% of the world's land area. Those nations possessing highly developed manufacturing areas have become the centers of economic, political, and world power. The higher standards of consumption accompanying this concentration of industry are envied by millions of people in less-industrialized lands (see Figs. 6 and 50-C).

To what extent and where is it possible to develop modern manufacturing on a broader geographic base? Which industries are footloose and which are likely to remain in their present locale? Where does manufacturing languish, and where does it thrive? How much? What kind? Why? These and other questions can be answered only by understanding the fundamentals of manufacture and by a careful study of specific industries. The problems of industrialization involve a keen appreciation of significant relationships existing between man and his environment.

Basic requirements of manufacture. Just as the position of the earth in the solar system at any time is the result of a balance of forces exerted by the sun, moon, the earth



Location of factories, F, somewhere between Raw Material, RM, and Market, M. Examples illustrate principles.

A. Footloose industry, anywhere along line
B. Canning reduces bulk and freight
C. Farm machinery increases bulk and freight
D. Steel materials assemble and then reduce bulk
E. Aluminum, Power. See Kitimat (Fig. 12)
F. Great Plains wool to eastern city labor and back West to market

Adapted from G. T. Renner, Economic Geography, July 1947

itself, and other planets, so the location of manufacturing is determined by a combination of forces and factors. The manufacturer must have access to markets, raw materials, and sources of power.[1] This involves the movement of commodities, and so he seeks a location that minimizes transportation costs. He must also have low production costs, and this involves access to labor and capital in addition to less important factors. In every case the location and development of manufacturing depend largely upon a combination of these basic factors—markets, materials, and power together with labor and capital. These are of varying relative importance to different industries. Here one and there another seems to dominate, but all are essential in order that manufacturing may develop and thrive.

2. LOCATIONAL FACTORS AND FORCES

Access to market. The manufacturer must have a market—people with a desire for goods and the ability to buy them. Wherever there are few people and a high degree of isolation man must be a "jack of all trades," for the market is too small to permit much specialization and the development of manufacturing as a separate occupation.[2] In such sparsely populated areas each family must make nearly

[1] No separate consideration is given here to land (site) as a locational factor. It is obvious that various industries have different space requirements and also that the natural quality of the land—topography, water supply, and climate—can favor or limit the development of industry. For a consideration of land as a factor in the location of manufacturing, see Edgar M. Hoover, *The Location of Economic Activity,* McGraw-Hill Book Co., New York, 1948, pp. 67–102.

[2] In 1776 Adam Smith pointed out that division of labor is limited by the extent of the market, and he observed, "In the lone houses and very small villages which are scattered about in so desert a country as the Highlands of Scotland, every farmer must be a butcher, baker and brewer for his own family. In such situations we can scarcely find a smith, a carpenter, or a mason, within less than twenty miles of the same trade. The scattered families that live at eight or ten miles' distance from the nearest of them, must learn to perform themselves a great number of little pieces of work, for which in more populous countries they would call in the assistance of those workmen." Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations,* Book 1, Chapter III.

everything that it needs, using local materials and simple hand tools. Such primitive manufacturing has been found along every frontier in history. Although disappearing before the advance of trade, it is found among the Eskimos, the nomadic tribes of central and northern Asia, the forest peoples of interior Africa and South America, and the mountain folk in parts of Europe and the United States.

In sparsely populated areas where the purchasing power per capita is high and where man has cheap and easy transportation, there is little primitive household manufacturing, since man can import from distant sources most of the manufactures that he needs. Small enterprises are to be found in the widely scattered villages and towns, but the limitations of the market, the lack of labor, and the greater reward that capital finds in other industries prevent manufacturing on a large scale. Such is generally the case in the pastoral and agricultural regions of Australia, New Zealand, Argentina, South Africa, Canada, and the United States.

In densely populated areas where transportation facilities are poor and where a low purchasing power per capita prevails, manufacturing remains decentralized in workshop and home. This is true of a large part of southern and eastern Asia, where millions are so poor that they must make by hand in their homes many of the things that they wear and use. In this land of teeming millions, manufacturing for centuries has been subsidiary to agriculture, which gets first choice of labor, capital, and land. While the typical workshop is small, the total output of handicraft manufacturing is large, since the huge population must obtain the necessities of life. Here in workshop and home has developed the skilled craftsmanship for which the Orient has long been famous.

Wherever the steamship, the railroad, and the foreign trader have penetrated the Orient, many a handicraft industry has been ruined by the cheap machine-made goods imported from the Occident. Handicraft industry has also suffered greatly in those localties where modern factories with power-driven machinery have arisen. Because purchasing power is so low, individual purchases of factory-made goods are small and limited in variety, yet in the aggregate the market is large. Already modern manufacturing has developed in favored spots, especially the production of such consumer goods as textiles, clothing, shoes, and light metal wares. There is every indication that such manufacturing will continue to spread. Yet many a home industry hangs on in all continents because the worker who might buy factory stuff has nothing to sell for cash with which to buy.

Northwestern Europe and northeastern United States are the world's greatest producers of manufactured goods and at the same time are the largest markets for their own wares. Both these regions had developed an important handicraft industry and a flourishing commerce before the Mechanical Revolution. As a result of the Mechanical Revolution, both the population and wealth of these two regions grew enormously. In an ever-expanding market, manufacturing, transportation, commerce, and finance developed rapidly, each stimulating the others.

Within these two regions are found today dense populations, great mobility of goods and men, and a high purchasing power per capita. These combine to make the world's greatest markets for goods of every kind and description.[8] Vast quantities of foodstuffs and raw materials are brought from the far corners of the earth for manufacture, and from the factories of these two regions are shipped innumerable finished goods to consumers in local and nearby markets and to men in many distant lands (see Fig. 274 and Fig. 371).

The market factor is of special importance

[8] A study of 88 large factories which located in southern United States since World War II revealed that 45% were primarily oriented toward their market. Material- and labor-oriented plants accounted for 30% and 25% respectively. Glenn E. McLaughlin and Stefan Robock, *Why Industry Moves South,* National Planning Association, Washington, 1949, p. 26. See also C. D. Harris, "The Market Factor in Localization of Industry in U. S.," A. A. G. *Annals,* Dec. 1954.

to certain types of industries. Among such industries are those in which transportation charges comprise a large part of the selling price of the finished product if it is transported very far, such as cement. Industries in which the finished product is more bulky than the raw materials are also pulled toward the market, such as the manufacture of agricultural machinery, printing presses, and large machine tools. The bottling of soft drinks, because of great bulk, occurs in the midst of the market. Cheap furniture, boxes, barrels, and crates are usually shipped knocked down, to be put together upon arrival at their destination. Likewise, in the automotive industry, engines and other major parts are often produced in Detroit and shipped to widely scattered plants in regional market centers for final assembly.

Nearness to market locates the manufacture of highly perishable finished products, such as baked goods and ice cream, and various service and repair industries that must meet customers' specifications.

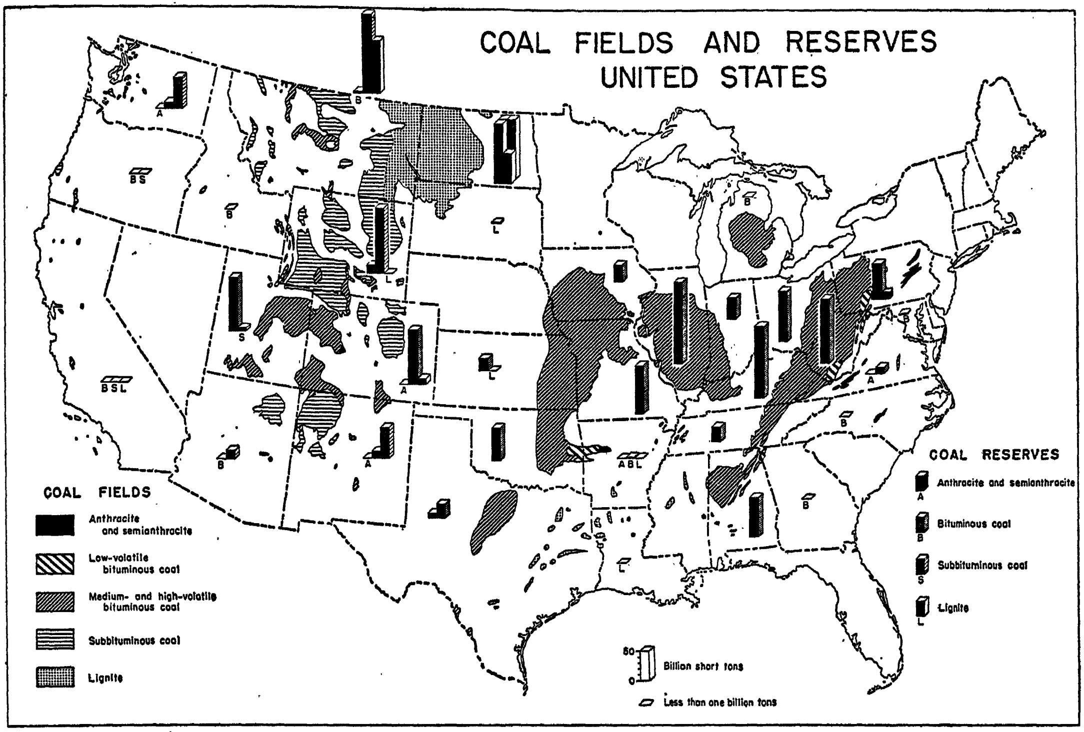
Access to raw materials. A second factor that is fundamental to all manufacturing consists of access to raw materials. The manufacturer must have relatively cheap raw materials or his costs may be prohibitive. With every improvement and cheapening of transportation, the manufacturer is able to reach farther for his raw materials as well as to serve more distant markets. The primitive household manufacturer, located in a sparsely populated area that suffers from a low purchasing power per capita and poor transportation, must rely upon local raw materials. In contrast with him, the modern manufacturer of northeastern United States and northwestern Europe, can profitably use materials that have been carried halfway around the world to his factory door.

In spite of the continued cheapening of transportation, certain types of manufacturing necessarily are located near their raw material source. This is particularly true of simple manufacturing using low-valued, heavy, and bulky raw materials, such as the manufacture of bricks from common clay, the ginning of cotton, and the sawing of lumber. In processing ores, bulk reduction is frequently achieved, as in production of copper matte and blister copper, the higher valued semifinished product being better able to stand transportation costs to distant markets. Both perishability and bulk of the raw material pull certain industries toward their raw material source, such as the manufacture of butter and cheese, the extraction of raw sugar from cane or beets, and the canning and freezing of fruits and vegetables.

Access to power. Without power, nothing on this earth can move. All work is merely energy manifested in time and space. All industries, indeed all forms of work, are directly dependent in the first instance upon some form of power. This may be manpower, animal power, wind power, water power, or the power derived from burning wood, gas, petroleum, or coal. As yet, atomic power has not been harnessed for peacetime industrial use.

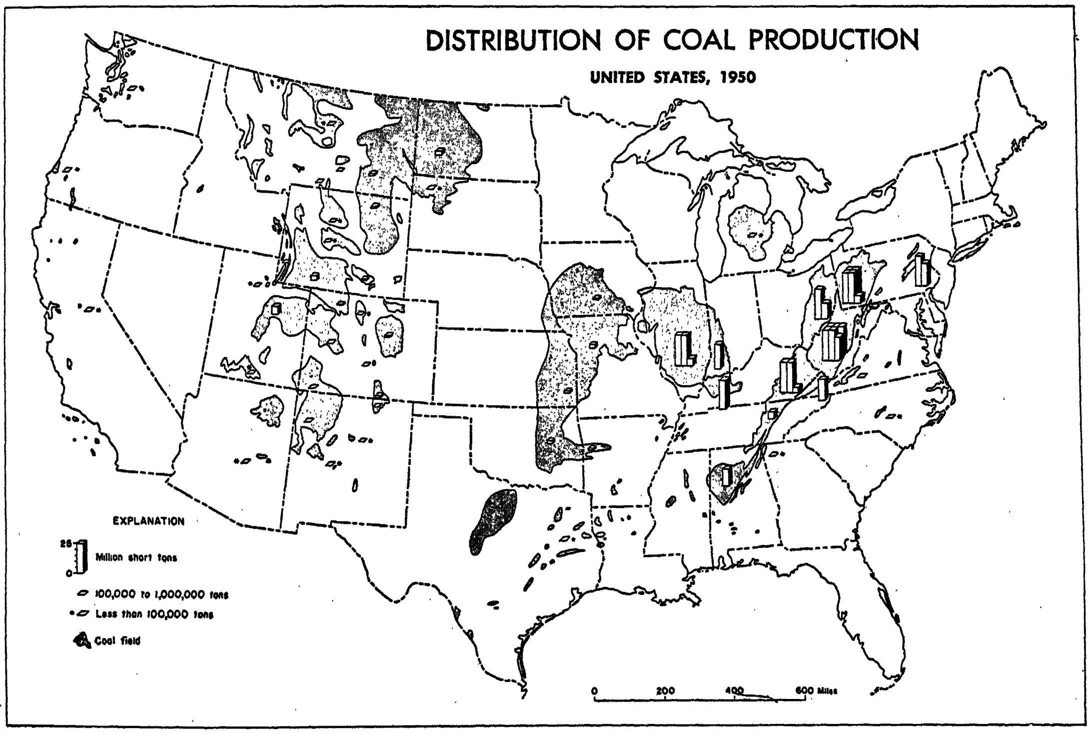
Where primitive manufacturing occurs in workshop and home, the sole source of power may be manpower, such as that of the skillful fingers which turn the spinning wheel or push the shuttle across the hand loom. The power-driven machines in modern factories depend upon the inanimate energy derived from fossil fuels and water power. Today the prime source of power is coal, which supplies more than one half of the world's total mechanical energy. Coal is followed in importance by petroleum, natural gas, and water power. The production and use of natural gas is confined largely to the United States and the Soviet Union. With unequaled access to power resources, northeastern United States and northwestern Europe have become the world's greatest manufacturing regions.

The first factories in England to use power-driven machinery were the little textile mills equipped with simple water wheels that, of necessity, were located along streams. Likewise, the first factories in New England were located at water-power sites, and as late as 1850 about 60% of the machinery in American factories was turned by water power.



(Above) U. S. Geological Survey reports 950 billion tons recoverable: of total of 1700 billion. Our mineral fuel, 82% coal, 2% petroleum, 2% natural gas, 12% oil shale. *U. S. Geological Survey*

(Below) Look carefully at the graphs for production, and note the insignificance of the West. *U. S. Geological Survey, 1953*



With the perfection of the steam engine, power made the first step in mobility. Coal, the source of power, could be hauled from the mine mouth to a more desirable point of use, a mobility that was made possible by the development of steam transportation. Yet, while coal could be moved cheaply long distances by water, it could not be moved far overland without greatly increasing its cost. Furthermore, once coal was delivered to the factory and converted into steam, the power had to be used on the spot, so each manufacturer was obliged to build and operate his own power plant.

For more than 100 years after the perfection of the steam prime mover by Watt, transmission of power from the engine to the power-driven machines was entirely by mechanical means such as belts, chains, ropes, discs, cams, levers, gearing, and shafting. . . . While Watt's improvement of the steam engine marks the beginning of the Age of Mechanical Power, the greatest impetus to its use occurred in September 1882 when the Pearl Street electric generating station was started in New York City.[4]

As electricity proved to be an efficient power-transmission medium, power-driven machinery no longer had to be close to the steam engine or the water wheel. Today most manufacturers obtain their power from the electric transmission line far more cheaply and in much more convenient form than they could produce it themselves. The development of the electric-power industry in the United States has been truly phenomenal. The output increased from 2½ billion kilowatt-hours in 1902 to 442 billions in 1953 (see Fig. 277).

Power has been made more available by every reduction in the cost of producing coal, petroleum, and natural gas, by every cheapening in their transportation from producing field to power plant, by every increase in the efficiency of steam- and hydroelectric-generating plants, by every improvement in transmission technique, and every extension of interconnection among electric-power systems. These developments have reduced the importance of power sources as a locational factor for industry. As never before, the manufacturer is freer to locate in response to the influence of other locational factors, but the percent of power cost to total cost is always a variable from industry to industry and location to location.

Despite the increased mobility of power, industries in which power costs loom large are especially attracted by the availability of cheap and abundant fuel and power. Nitrogen-fixation plants, aluminum and other electric smelting plants, pulp and paper mills, electroplating establishments, and plants manufacturing abrasives are among those locating near water-power sites, where power is so plentiful and cheap. Accessibility to coal and coke is an important factor in the location of iron and steel production, while the manufacture of glass requires an abundant supply of gas.

Transportation and industrial location. In manufacturing everything must be moved. Transportation is a service by means of which the varying influence of markets, materials, and power are exerted upon the location and development of manufacturing. The transport factor functions through its influence on cost of raw materials or of reaching market. The existence of a varied and low-cost transportation network favors the growth of industry, but its influence varies from industry to industry because of rates of weight and value and the nature of product and raw material. Cheap transport is always desired, and here water transport is usually king. The great industrial-commercial regions of northwestern Europe and northeastern United States have the most highly developed transport networks in the world. No point within either region is farther than 10 miles from a railroad. Both have dense networks of highway and air routes, and both have highly developed ocean and inland-water transport. Although the speed-minded and rubber-tired American has lagged behind the

[4] National Resources Committee, *Technological Trends and National Policy*, Washington, June 1937, p. 254.

Ram Kari Yadava

Lake traffic requires 48 locks between Superior and Huron. Four locks, two ore boats, a busy, busy spot. ***Steelways, American Iron and Steel Institute***

European in his dependence on inland waterways, it is true that the 21 largest cities in the United States are located upon navigable water.[5]

Low freight rates really make transport facilities function. Freight rates are generally low in regions producing a large volume and variety of traffic, especially if it moves in both directions along the route that is served by the boat, train, truck, or plane. In regions that produce little traffic, and especially if it moves in one direction, freight rates are generally high.

For the industrialist seeking a location, therefore, the availability and cost of transportation is a primary concern. In the long run, however, it may be said that transport facilities will be developed if an area's combination of the other basic factors is favorable for industry.

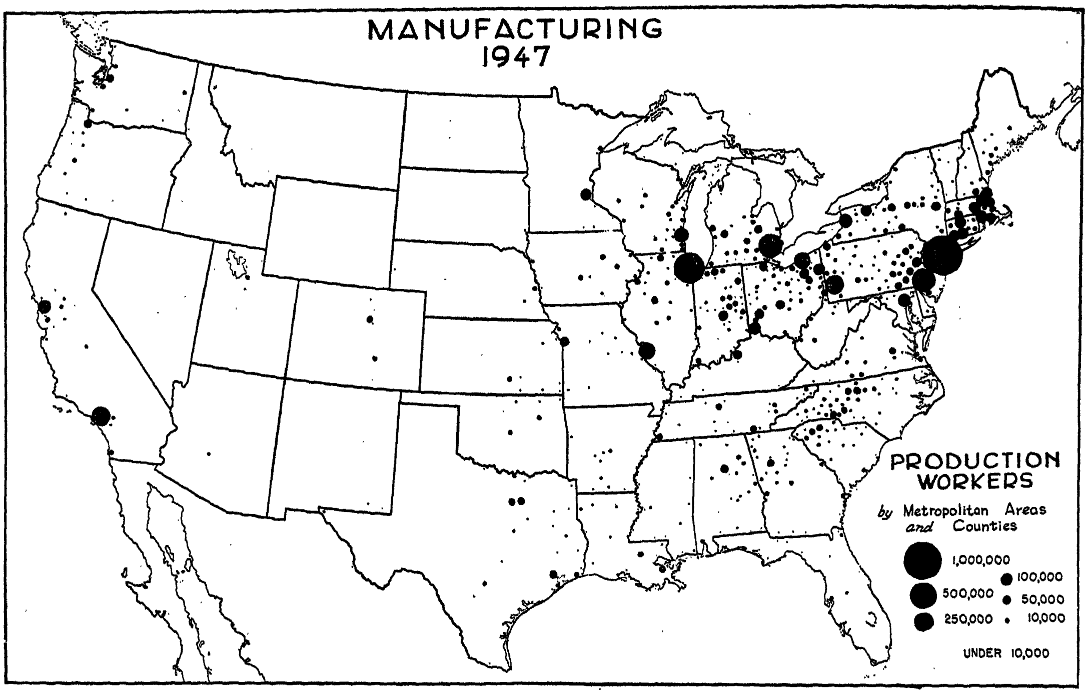
The remaining two factors, labor and capital, are not so closely related to the movement of materials and the problems of transport costs.

Access to labor. In spite of all our machinery, the manufacturer must use some human labor. In many densely populated areas there are few resources per person, and wages tend to be low. The people must bid for jobs, and they make the products in which labor cost per unit is a high percentage of the total. Thus southern and eastern Asia produce raw silk and handwrought curios; northwestern Europe, the refined machinery; the United States, the stuff from the heavy assembly line. Dense population is a magnet to draw manufacturers. In large urban centers the opportunity to work for others and the chance for specialization are greatest. Here man finds a wide field of employment not only in different types of manufacturing but also in trade, clerical occupations, domestic and personal service, transportation and communication, and professional and public service.

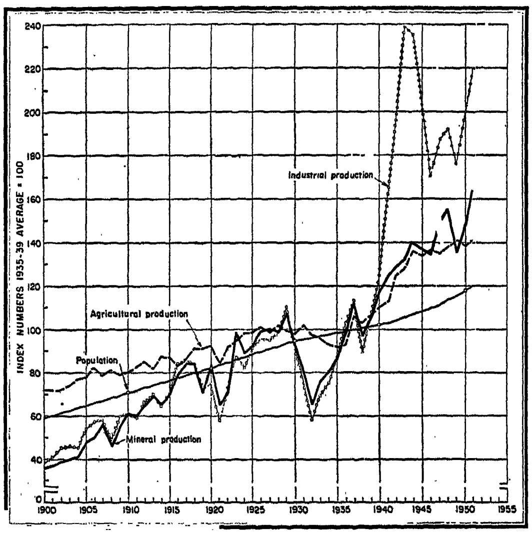
With its large-scale production methods, power-driven machinery, and minute division of labor, modern manufacturing offers employment to workers with all types and degrees of skill. Many jobs of operating machines can be learned in a very short time. In countries with well-developed transportation facilities the mobility of labor is greater than ever before, and man has a chance to move to jobs that suit his taste and that offer the highest wages.

Manufacturing, of course, must compete at all times with other industries for the use of labor. In this respect the American manufacturer of today is much better off than the manufacturer of a century ago, who was con-

[5] The 21 largest cities in 1950: New York, Chicago, Philadelphia, Los Angeles, Detroit, Baltimore, Cleveland, St. Louis, Washington, Boston, San Francisco, Pittsburgh, Milwaukee, Houston, Buffalo, New Orleans, Minneapolis, Cincinnati, Seattle, Kansas City (Mo.), and Newark



Offshoots grow out of the original manufacturing triangle—southern Maine, Chicago, Baltimore. Today's figures would show more in Midwest, southern Piedmont, Gulf Coast, Pacific Coast. ***Courtesy of Prof. John W. Alexander, University of Wisconsin***

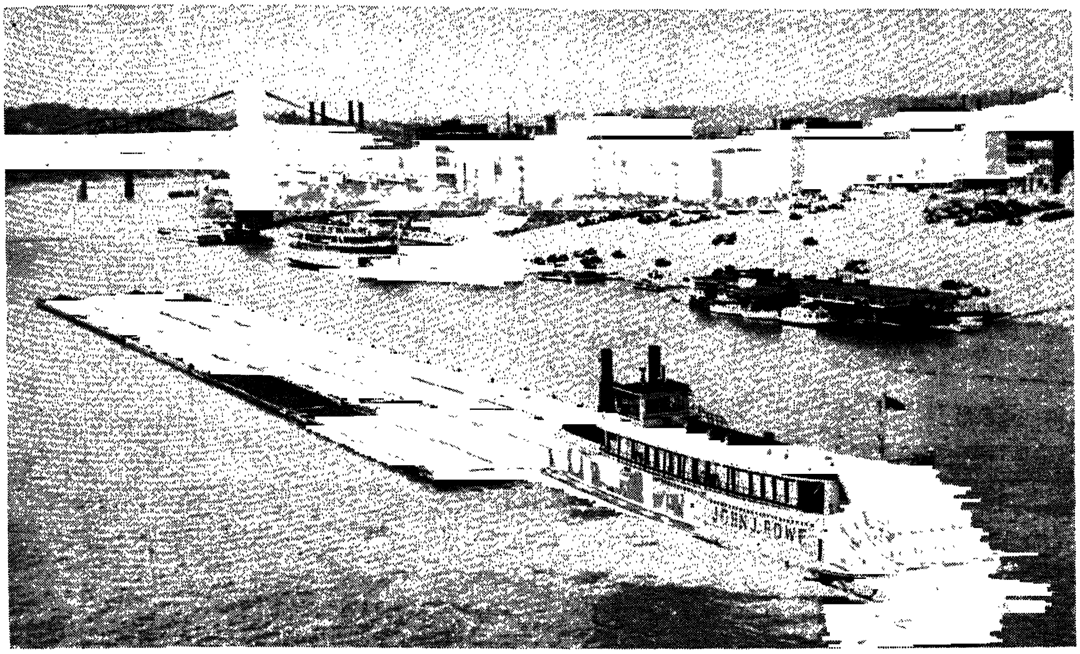


This graph of men and physical volume of 3 main economic factors shows our increasing dependence on minerals and manufactures. War a spire, depression a hole. ***U. S. Bureau of Mines***

fronted by a westward migration of men and their families who were staking their fortunes in the development of our continental interior.[6] Since the frontier and the opportunity to acquire good land at little or no cost have vanished in the United States, since power-driven machinery is displacing both man and beast on many a farm, and since the inflow of European immigrants has dwindled to a mere trickle, the siren call of factory wages has lured millions of Americans from the farm and village into the great urban centers. For the manufacturer, this migration of men to cities and suburban areas has a double significance —it steadily increases the urban and suburban markets for his goods and at the same time provides him with a growing supply of labor.

While there is a great variation in labor requirements among manufacturing industries, there are certain types of manufacturing

[6] For a discussion of old and new frontiers, see Frederick Jackson Turner, *The Frontier in American History,* Henry Holt & Co., New York, 1920; J. Russell Smith and M. Ogden Phillips, *North America,* Harcourt, Brace & Co., New York, 1942, pp. 1–37; and Edward L. Ullman, "Amenities as a Factor in Regional Growth," *The Geographical Review,* January 1954, pp. 119–132.



Fundamental. Paddlewheel river steamship. West Virginia coal, 18,000 tons for Cincinnati. Coal can float cheaply, Appalachia and Illinois to St. Paul, Kansas City, Knoxville, New Orleans, Mobile, Houston, Corpus Christi. *Ohio River Co.*

that are attracted by the presence of cheap labor. This attraction is especially important to those enterprises that operate on such a slender margin of profit that they must pay low wages in order to exist. The production of Persian rugs and other articles of Oriental handicraft requiring long hours of cheap and skilled labor is impractical in the United States. We make clever machine-made imitations. The manufacture of lace, embroidery, and textiles in Puerto Rico and the production of tailor-made clothes in European cities are dependent upon cheap labor. For many years the migration of the cotton textile industry in the United States was definitely a movement toward cheap labor that could be easily trained.

If skilled labor is an outstanding factor in production, the manufacturer who sets up a new factory is likely to be attracted to those areas where skilled labor is already available. Sometimes a manufacturer finds it necessary to take skilled labor with him. Thus, skilled Pittsburgh labor was brought to Gary when the steel industry was established there in the early years of this century. Shoemaking operatives moved from Massachusetts to St. Louis to start new enterprises. In 1954 an electrical manufacturer moved from Philadelphia to Kansas City and took all workers who would go.

In the long run, neither cheapness of labor nor skill of labor is a permanent advantage. The development of industry in a cheap-labor area, especially in the United States, ultimately results in educational processes that produce an increase in wages until the labor advantage virtually disappears, a trend that is now occurring in our southern states. Similarly, labor skill in machine industries is not a monopoly of any specific group or area, and, over a period of time, a labor force can be trained to perform most of the operations in modern manufacturing. Finally, labor is highly mobile, especially in the United States, and tends to seek the best job opportunities. World War II saw many thousands of workers flocking to war plants, some of which were located in distinctly out-of-the-way places. The increase of population in California, 1940–50, is

an outstanding example of voluntary mobility.

Access to capital. Although capital is indispensable to the development of manufacturing, this does not mean that the factory must be near the supply of capital funds. An industry may be located with good reason near the market, raw materials, power resources, or labor supply, but industry rarely if ever moves toward capital. In normal times capital funds flow freely. They fly from the great metropolitan centers of finance, such as New York and London and Amsterdam, to the most remote and desolate spots in the world—if the capitalists think there is reasonable security and a good chance for an adequate return on investment. Of all the factors contributing to the development of manufacturing, capital is the most mobile. It is also skillful at shunning good resources located in places where government and morals make risks.

The force of locational concentration. It is clear that markets, materials, power, labor, and capital are indispensable to the development of every manufacturing industry. In conjunction, they determine its location. Few industries are located primarily by the heavy influence of a single factor, and many can find a favorable combination of factors in a number of different locations.[7] This means that the industrial areas themselves become a force, almost a separate factor, influencing the location of industry.

Huge agglomerations of factories are characteristic of modern manufacturing regions—the Pittsburgh-Buffalo-Chicago industrial triangle, the industrial seaboard between Portland, Me., and Norfolk, Va., the English Midlands, the Ruhr-Lorraine-Calais triangle, and the Moscow-Gorki, Ukrainian, and Ural districts of the Soviet Union. These are the industrial giants, areas possessing a favorable combination of the basic factors discussed above.

The agglomeration of industry is itself a market, and also a magnetic force attracting new industry and strengthening the locational pull of the fundamental factors. The complexities of modern industry often cause one factory to produce the "raw" materials for the next—textiles for the clothing factory, grease for the soap factory, metals and parts for a host of metal-fabricating plants, and coke by-products for the chemical industry. It follows that the market for many manufactures is another factory. Hence, many manufacturers find it advantageous to locate near other manufacturers to reduce the distance of shipments and to reap the advantage of lower freight rates along the heavy traffic arteries within major industrial areas.

Low costs of production may also result from the concentration of manufacturing in any particular center or area. Locational concentration allows the small manufacturer to specialize his products and provides him with a variety of materials, services, and market outlets not so conveniently available in a less-industrialized setting. For the industry in which large-scale operations mean low cost, the concentration of manufacturing provides the necessary large supplies of materials, power, labor, and capital, as well as access to excellent transportation facilities and to large and diverse markets.[8]

These advantages of concentration give to the established industrial area a momentum and attractive force that may persist long after the importance of original advantages has waned or has been threatened by the emergence of a rival area. The problems of industrial areas that have lost some of their original advantages and are now suffering from the competition of robust rivals are not easily solved. Witness the problems of New England and old England today! Indeed this is likely to be a continuing problem.

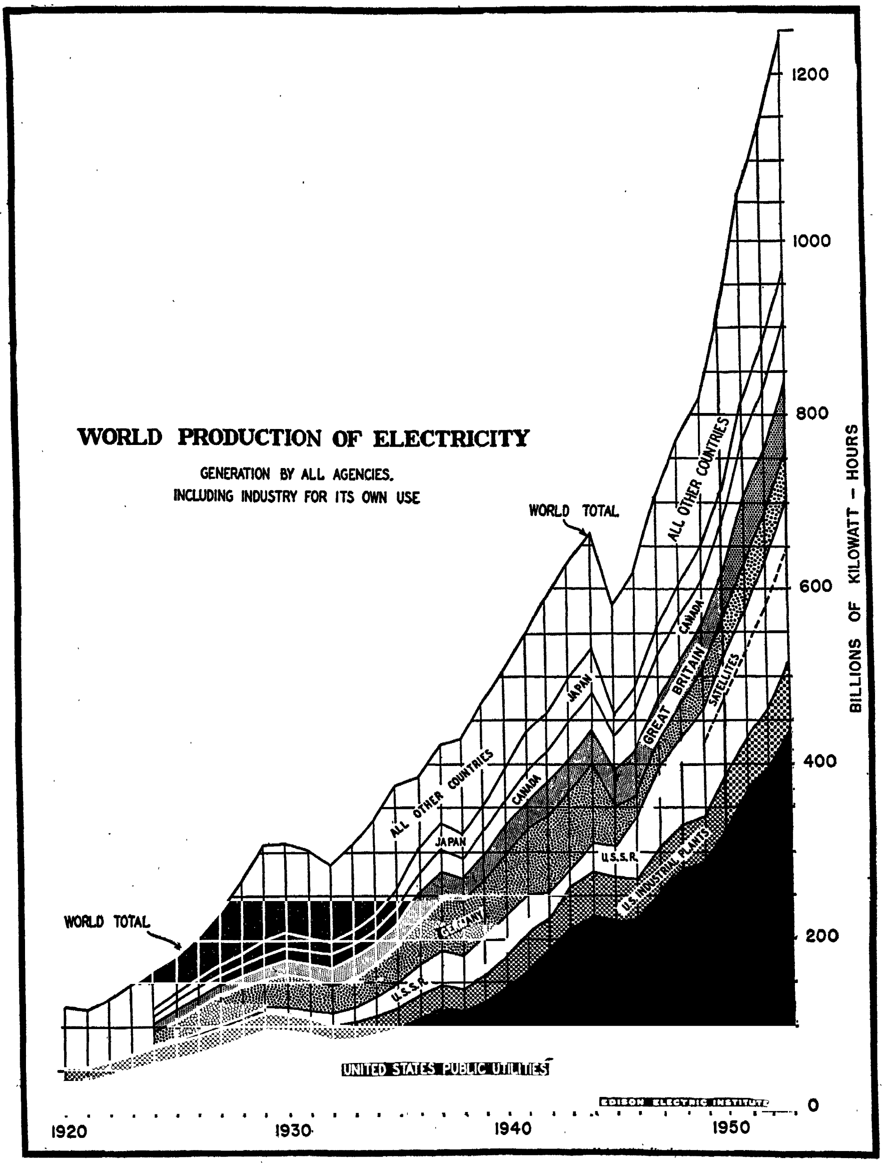
---

[7] See George T. Renner, "Geography of Industrial Location," *Economic Geography*, July 1947, pp. 167–190, and Wilfred Smith, *Geography and the Location of Industry*, The University Press, Liverpool, 1952.

[8] It must be remembered that the advantages of locational concentration are not without limit. A point is eventually reached when the advantages are outweighed by the costs of congestion—increased inconvenience and cost in movement of goods and people, together with higher rents, taxes, and wages. At such a point many an industry closes its doors and migrates to a new and better location. See Hoover, *op. cit.*, pp. 78–89.

Miscellaneous factors. Other factors, it is true, sometimes enter into the equation of industrial development. A stimulating climate creates human health and energy. This aids manufacturing as it does all forms of human activity. Sometimes the location and concentration of a given industry in a particular city are the result of pure historical accident, as was the development of the automobile industry in Detroit, the manufacture of rubber in Akron, the Kodak industry in Rochester, glove manufacture in Gloversville and Johnstown, N. Y., and the manufacture of shirts and collars in Troy, N. Y. It should be noted, however, that all these industries have good locations and survive when many others have fallen.

No discussion of the location and development of manufacturing would be complete without mention of the increasing penetration of government into the field of business. Government aid to manufacturing occurs in many different forms, and it varies in amount from a few hundred dollars to hundreds of millions.



Power—This graph merits close examination. It tells much. *Edison Electric Institute*

Some village may offer a free factory site to a prospective manufacturing concern, or some enthusiastic town council may vote to exempt the new industry from local taxes for a number of years. Some industries are lured to certain states, where corporation taxes are low or where laws governing the treatment of labor are lax.

Every national government at some time or other has endeavored to stimulate manufacturing, or certain kinds of manufacturing, through a high protective tariff, which restricts foreign competition and generally enables the manufacturer to charge a higher price for his product. Many a nation has granted outright subsidies to various types of manufacturing, the cost of such aid falling upon the taxpayers. Sometimes the national government makes huge loans to manufacturers at low interest rates and under easy terms of repayment. In some countries large manufacturers are encouraged or compelled to form great cartels or monopolies in which government funds are often invested.

Whether governmental aid as a general policy or in particular cases is wise or not is a moot question that can be decided fairly only in view of all the circumstances involved. Nevertheless, a few facts are certain. Whether governmental aid is large or small, direct or indirect, private enterprise continues to determine the location and development of most manufacturing. The public pays the bill for whatever governmental aid is given.

When the government enters manufacturing, it is the government that determines the location and development of industries. Sometimes the government decides to render additional services that would not be attempted by a profit-seeking corporation. Thus, the TVA not only produces electric power for sale to consumers at low rates but also has built and maintains a 9-foot channel for navigation on the Tennessee River and conducts a flood-control and soil-conservation program.

In the Soviet Union, where state socialism prevails, all large-scale manufacturing is conceived, developed, operated, and owned by the government. Here the government has made a stupendous effort to develop potential resources and to establish modern manufacturing at favorable sites throughout the vast Russian domain. Entire cities and gigantic industries were created within a few years' time, such as the great Siberian iron and steel center at Magnitogorsk.[9] The cost of such rapid industrial development cannot be measured alone in terms of statistics; it must also be reckoned in terms of the blood, sweat, tears, and privations of the Russian people. Only the Russian people know what the true cost has been.

Sometimes the military motive is a decisive factor determining the location of manufacturing. In prewar years many vital industries in the Soviet Union were deliberately located in the Ural Mountains and Siberia, remote from the western frontier. Such planning unquestionably helped to prevent the collapse of the Soviet economy when German armies invaded European Russia during World War II. With somewhat similar motives, but vastly different methods, a number of war-supply plants in the United States have been located deep in the nation's interior in the hope that they will be safer in the event of aerial attack. Western critics of the Soviet Union point to huge economic errors of the bureaucracy made by men who got their jobs politically, as must be the case when the government operates industry.

Britain is trying socialism in a democracy. All can vote. Do the workers move away when an enterprise fails? They prefer not to and they can vote. They petition government to send them an industry. Will it be an economic decision or a political decision? Have you made a study of the business influence of blocs in the American Congress? Silver? Wool? Steel? Butter?

3. MINERALS AND MANUFACTURING

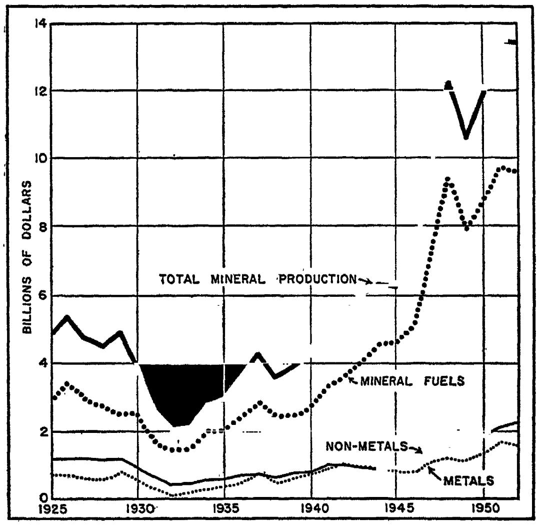
Importance of minerals in our modern Machine Age. Through modern factories

[9] For a dramatic account of the creation of this great iron and steel center, see John Scott, *Behind the Urals*, Houghton Mifflin Co., Boston, 1942. For the location of Russian industrial areas, see Fig. 298.

flows an endless stream of products from the animal, vegetable, and mineral kingdoms that bellow, squeal and grunt, rumble and thud, roll, slide, pour, and dump—and that make dust, smoke, noise, tonnage, values, jobs, wages, salaries, and profits as these products are converted from one form to another en route to the final consumer. Men and machines are directing and shaping this constant flow of products of field, pasture, forest, mine, and sea. Every machine is driven by some form of power. Without it all movement would cease.

The power that gives rise to the whole production process is the inanimate energy derived from the mineral fuels and falling water. The machine that harnesses the power and converts raw materials into myriads of things wanted by millions of men is made of metal. Minerals, therefore, are the source of the machine and most of the power that is used to run it. Without minerals there would be no power-driven machinery in manufacturing or in transportation, mining, farming, or any other economic activity. Without the power-driven machine there would be no modern manufacturing. Our modern Machine Age is based squarely upon a mineral foundation, and the greatest pillars of strength in this foundation are coal and iron.

Long-run growth of mineral production. Since minerals play such an outstanding role in modern economic life, a few salient features of mineral production will be considered. As the Mechanical Revolution got under way, man began to dig for mineral wealth as never before in all recorded history. His continued diggings have brought to the surface a truly unprecedented volume and variety of minerals, a trend that has gained momentum down through the decades and spurted in World War II. Indeed, in the first four decades of the present century, man used more of the world's mineral deposits than in all preceding centuries.[10] In general, it may be said that the world's output of minerals has long kept pace with industrial production. Since the bulk of the demand for minerals comes from manufacturing and transportation, mineral production is subject to the same fevers of prosperity and chills of depression that cyclically afflict modern industry. Yet the long-run trend of mineral output continues upward. However, there is eventually a day of reckoning when man will reach the end of the rope, since nearly all sources of minerals are exhaustible.



A grain of salt needed. Dollar shrinkage exaggerates period since 1933. Fuels outrank all else. ***U. S. Statistical Abstract***

The mineral life cycle. In view of the exhaustibility of mineral deposits, we can say their life cycle of production includes stages of growth, maturity, decline, and usually death. Since reserves are still adequate and new discoveries are being made, we may say that mineral production in the world as a whole is still in the stage of rapid growth. The Soviet Union, which has begun intensive mineral exploitation only recently, is in the stage of early and rapid growth. The United States has reached the state of maturity. Great Britain is definitely in the stage of decline. The long-used British deposits of tin, copper, lead, silver, and zinc are virtually exhausted, and the production of coal and iron is below the level reached in 1913.

The production of such new minerals as chromite, magnesium, titanium, and molybde-

[10] Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace,* The Brookings Institution, Washington, 1943, p. 1.

TABLE 16:1. Percentage of World's Total Mine Output of Important Minerals Supplied by Leading Producing Nations in 1950

Mineral	Largest producer		Second producer	
Antimony	Bolivia	26.0	Union of S. Africa	16.6
Asbestos	Canada	66.0	U. S. S. R.	18.0
Bauxite	Dutch Guiana	25.2	British Guiana	19.5
Chromite	U. S. S. R.	21.7	Union of S. Africa	21.6
Coal and lignite	United States	28.1	Germany	17.4
Copper	United States	33.1	Chile	14.4
Fluorspar	United States	34.7	Germany, West	18.4
Gas, natural	United States	88.5[a]	U. S. S. R.	3.5[a]
Gold	Union of S. Africa	36.9	U. S. S. R.	22.2
Gypsum	United States	35.9	Canada	15.7
Ilmenite	United States	48.4	India	24.6
Iron ore	United States	40.7	U. S. S. R.	11.0
Lead	United States	23.5	Mexico	14.4
Magnesium	United States	35.7	United Kingdom	12.2
Manganese ore	U. S. S. R.	36.4	Union of S. Africa	14.4
Mercury	Italy	39.2	Spain	36.8
Mica	India	75.0[b]	Brazil	5.0[b]
Molybdenum	United States	89.7	Chile	5.6
Nickel	Canada	77.0	New Caledonia	4.3
Petroleum, crude	United States	52.1	Venezuela	14.4
Phosphate rock	United States	49.0	French Morocco	18.0
Platinum	Canada	46.9[c]	U. S. S. R.	17.4[c]
Potash	Germany, West	40.0[d]	United States	26.0[d]
Quartz crystal	Brazil	93.0	China	3.0
Salt	United States	31.4	U. S. S. R.	10.4
Silver	Mexico	25.6	United States	22.0
Sulfur	United States	53.6[e]	Japan	8.3[e]
Tin	Malaya	34.6	Indonesia	19.3
Tungsten	China	36.5	United States	14.6
Vanadium	United States	55.1[f]	Peru	25.0[f]
Zinc	United States	26.7	Canada	13.4

[a] Data as of 1938.
[b] Block, films, and splittings only.
[c] Includes the platinum group metals.
[d] Based on potassium oxide content.
[e] Based on sulfur equivalent in native sulfur and pyritic material.
[f] Data as of 1947. Vanadium data are now restricted.
Source: All data, except natural gas and vanadium, were prepared by the U.S. Bureau of Mines on July 11, 1952. Natural gas data are from Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace,* The Brookings Institution, Washington, 1943, p. 38. Vanadium data for 1947 are from U. S. Bureau of Mines, *Minerals Yearbook, 1949,* Washington, 1951, p. 1264.

num is in the stage of early and rapid growth, whereas the output of many older minerals is no longer increasing as rapidly as it did several decades ago, and the number of dead mines is appalling. As mining penetrates deeper into the earth and as reserves approach depletion, the cost per unit of output increases. Hence, the output from any mineral deposit in time will slacken in its rate of increase and then decline and eventually cease.

In the case of particular minerals, the long-run tendency for production to slow up and then decline may be accelerated or retarded by forces beyond the control of the mineral producer. The tremendous increase in demand for many minerals during World War II greatly speeded up their life cycle of production and hastened their day of exhaustion.

The scientist, who often is both hero and villain, is continually finding substitutes. Such

Fundamental. Coal train runs down from Appalachia to the cities beside the sea; location of Appalachian coal favors industry in Northeast and Central United States. ***Bituminous Coal Institute***

progress is pleasing to the manufacturer and other consumers, but it may put a specific mineral producer out of business. Thus, the producers of sodium nitrate in Chile were nearly ruined by the competition of synthetic nitrate obtained from the air, coal, and other sources. Again, the scientist is always finding ways to increase the efficiency of mineral use, which greatly benefit the manufacturer and other consumers but which represent a decline in demand to the mineral producer and may cause him serious problems.

New alloy steels not only meet the needs of consumers better, but they require less iron and last longer. In 1953 only 1 pound of coal was needed to generate 1 kw-hr of electricity, as compared with 3.2 pounds in 1919. Furthermore, as a region's manufacturing grows larger and older, junk piles and scrap heaps increase in importance, since from them are salvaged larger and larger amounts of secondary or scrap metal that can be used again in production. While technological improvements that reduce the rate of mineral consumption may create serious problems for the mineral producers, they obviously benefit the consumers of today and those of posterity.

Poorer ores. Another outstanding trend in mineral production has been the shift from small, rich deposits to large ones that may contain leaner ores. In the days of pick and shovel, the individual miner or small mining enterprise usually preferred the most accessible deposit with the richest and purest ore, and the relatively small demand for minerals in those days could be readily supplied from a large number of small and scattered sources. Today, however, the enormous demand for minerals calls for large-scale mineral production. The giant mining corporation, frequently affiliated with great manufacturing and other mineral-consuming industries, has a tremendous investment in heavy and expensive mechanical equipment that cannot be dismantled and moved about except at great cost. Hence, the big mining corporation tends to concentrate its operations in those mineral fields where reserves are largest, even though they may lack the richness, purity, and accessibility of smaller deposits. This development of large-scale mining operations converging on the largest mineral reserves has been part and parcel of the growth and integration of big business, a development that generally has

brought about a lower cost of mineral products for the manufacturer and other mineral consumers.

Concentration of mineral production and consumption. Finally, it should be emphasized that a remarkably large portion of the world's mineral production lies under the control of a very few nations (see Table 16:1). Of the total value of the world's mineral output in 1939, about 34% was produced in the United States, 23% in the British Empire, 10% in Russia, 7½% in Germany, and 6% in the United Kingdom.[11]

A postwar survey reveals that eight nations consume 85% of the world's mineral output and produce over 80% of all manufactured goods, namely, the United States, Great Britain, the Soviet Union, Belgium, France, Germany, Italy, and Japan.[12] With the exception of the Soviet Union, all are increasingly dependent upon imports of minerals. For decades the Americans and British have been the leading exploiters of minerals, because of their extensive ownership of mineral production in foreign countries. Indeed, it is probable that they control three fourths of the world's total output of minerals.

As the Mechanical Revolution gave rise to the factory system in Great Britain, northeastern United States, and western and central Europe, from these areas came the increasing demand for minerals that in time caused the industrialists of these regions to reach into distant lands for a greater volume and variety of mineral supplies. Today we find a gigantic power belt extending from the Mississippi valley eastward across the United States, Great Britain, western and central Europe, onward into European Russia and Siberia.

Within this belt is consumed more than 90% of the industrial energy derived from coal, petroleum, and water power. While this power belt is by no means a continuous manufacturing region, nevertheless within this belt is to be found the most important and highly developed manufacturing on earth, including more than 90% of the world's pig-iron and steel-producing capacity. In contrast with this North Atlantic power belt, the entire Southern Hemisphere produces less than 3% of the world's coal, petroleum, and water power; and it has less than 2% of the world's iron and steel industry and an almost equally low percentage of other mineral-consuming industries.[13]

While manufacturing centers are arising in favored spots in Japan, China, India, Australia, South Africa, Brazil, Argentina, Chile, and elsewhere (see Fig. 50-C), none of these outlying centers possesses the favorable combination of markets, raw materials, transportation facilities, labor, capital, security, and power resources that are to be found in such a supreme degree within the North Atlantic power belt. As to the future—

> For a long time to come, the mineral resources of all the world will be mainly tributary to the industrial countries of the North Atlantic. Moreover, it is now pretty certain that the heavy industry of the outlying parts of the world will never catch up with that in the centers already established. This is because the basic supplies are not there on the scale available to the established industries of the North Atlantic. The industrial countries within the power belt must exchange minerals among themselves, and will continue to reach out to all parts of the world for additional supplies. The countries outside this belt will contribute whatever mineral supplies they have, together with other raw materials, in exchange for manufactures.[14]

Thus it is apparent that from nature's great geological lottery a few nations were given easy access to peerless energy and machine resources, an advantage that has placed in their hands so much wealth and political power. This is probably the most important single fact in the geography of modern times.

[11] *Ibid.*, pp. 224–226.

[12] See E. Willard Miller, "Some Aspects of the Mineral Position of Eight Principal Industrial Nations," *Economic Geography*, April 1950, pp. 133–143.

[13] Leith, Furness, and Lewis, *op. cit.*, p. 32.

[14] *Ibid.*, p. 33.

17· Coal—Prime Source of Energy

1. THE ORIGIN AND IMPORTANCE OF COAL

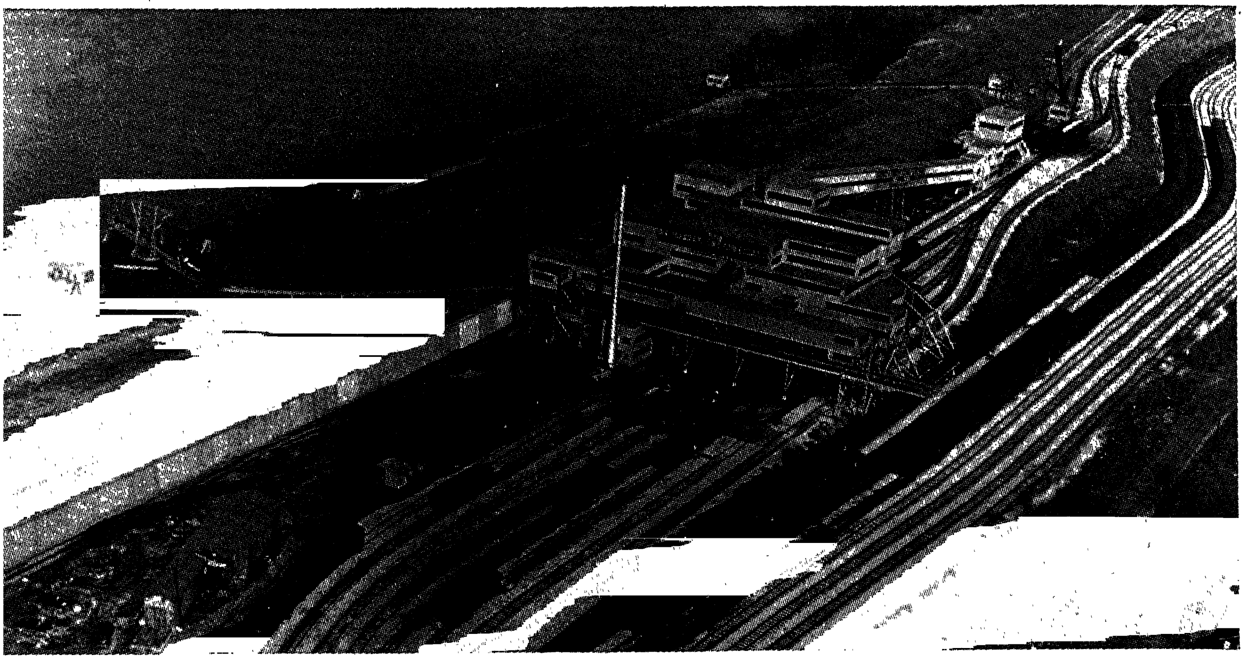
A priceless legacy. You may inherit from father or grandfather, but the human race has inherited from the remote past. Some 250 million years ago much of the world was warm and damp and green. Vast swamps were covered by a most luxuriant growth of vegetation. There were thousands of species of plants, varying from minute algae to giant ferns and huge trees. The air teemed with spores of plants and buzzed with a profusion of insects, and great dragonflies darted hither and yon. Shallow pools abounded with fish. Lizardlike 3-eyed amphibia slithered into and out of the water. Some 800 species of cockroaches scampered about with no human hand or foot to molest them.

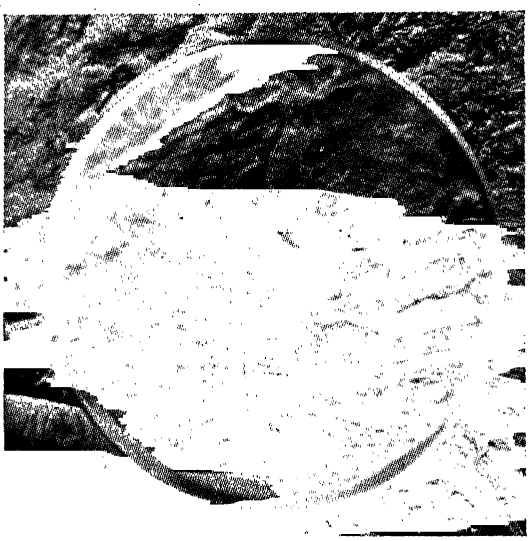
In this swampy environment coal was being formed. As the plant life breathed in the carbon dioxide from the air and assimilated the carbon, the first step in coal making occurred. Leaves, stalks, bark, and wood fell into the water. This mass of organic material partly decayed, but acids were formed that arrested further decay. As the remains of plant and animal life accumulated on the swamp floor, the debris below in the form of peat was compressed, and some of the water was squeezed out.

After the earth's surface submerged, a layer of sand, clay, or lime was in time deposited upon the peat bed. The pressure of these sedimentary deposits squeezed out much more of the water, fats, and gas and, together with heat and chemical changes, transformed the peat into a harder substance of higher carbon content, or coal.

When the earth's surface emerged later, another jungle grew, resulting in the formation of another layer of swamp vegetation which went through the same peat- and coal-forming process. Thus, through repeated submergence and emergence of the earth's crust, nature made a colossal "club sandwich," with layers of coal alternating with sedimentary rocks. Sometimes the pressure was later increased by folding or warping of the earth's crust, and the result was a harder type of coal. Indeed, about 400 feet of compact vegetable debris were severely compressed to make anthracite coal 50 feet deep in the Mammoth Bed of the Schuylkill field in eastern Pennsylvania.

The geologist is a shrewd detective always searching for clues, and with the naked eye he can sometimes see the imprints of leaves and stalks in a lump of coal. With his microscope he can see plant-cell structures. He knows that coal is preserved and compressed vegetation that once lived and breathed the carbon dioxide out of the air in a swampy environment a long time ago. He knows that in the most





(Above) **West Virginia coal. Mine entrance at arrow. Cars roll to building: coal on belt conveyor to barges, 1000 tons an hour. Compare Fig. 275.** ***McNally, Pittsburgh Manufacturing Corp.*** ***(Left)*** **Fossil plants in coal measure.**

favorable circumstances about 300 to 400 years were required for the formation of one foot of coal.

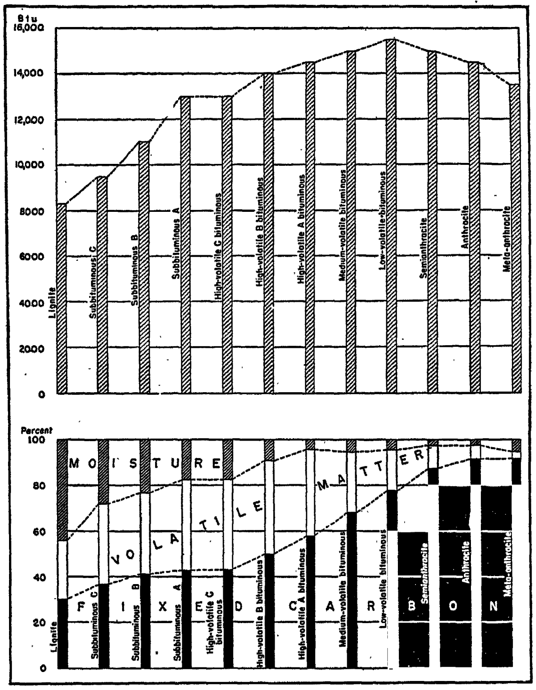
The nature and use of peat. In some places the process of coal formation has been under way such a short time that only peat has been formed. This brown, fibrous, unsolidified substance is not even classified as coal. When dug out of a bog, it contains about 85% water, 10.4% volatile matter, only 4.6% carbon, and a variable amount of ash. It must be dried before it can be burned, and even then it yields a lot of smoke and little heat. Peat is a common household fuel in parts of Ireland, Poland, and Germany, but the Soviet Union consumes more than all other nations combined.

The industrial importance of peat is negligible except in the Soviet Union, where peat ranks second only to coal in the production of electric power. The Russians have built generating plants in the midst of the peat bogs near Leningrad, Moscow, and Gorki. At Balakhna near Gorki is a plant with an installed capacity of 204,000 kilowatts, the world's largest power plant using peat as fuel. Peat electric plants account for about 18.5% of the total output of electric power in the Soviet Union today.[1]

[1] Eric Thiel, "The Power Industry in the Soviet Union," *Economic Geography,* April 1951, p. 110.

Types of coal. As previously indicated, coal is peat that has been subject to additional pressure. It was the pressure involved in coal making that primarily determines the quality and types of coal available to man today. In general it can be said that the greater the pressure, the harder the coal, the higher the fixed carbon content, and the lower the amount of moisture and volatile matter. Hence, in order of increasing hardness, we find three main groups or classes of coal, namely, lignite, bituminous, and anthracite.

Lignite is the softest and lowest type of coal, and it varies greatly in quality from place to place. This brown, woody coal contains the largest amount of moisture and volatile matter and the least amount of carbon among the various classes of coal, and it ranks lowest in heating value (see Fig. 285). It cannot be handled much without crumbling, and it cannot be stored long without danger of spontaneous combustion. Because of these qualities and its general low value, lignite is seldom transported far from the mine.



Lower table is analyses of U. S. coal, 1953; upper table, heat value in British thermal units per pound. *U. S. Geological Survey*

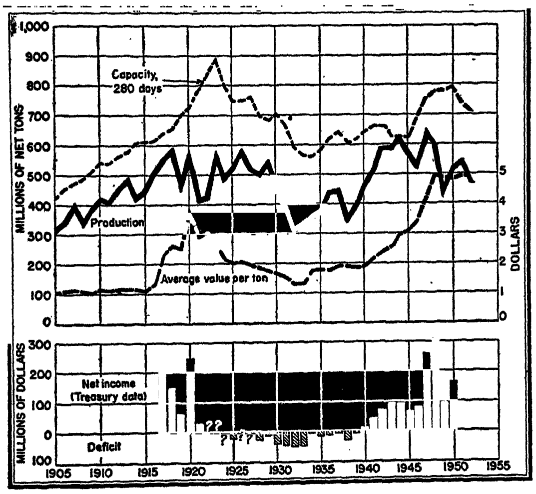
About 52% of the world's lignite (in terms of bituminous coal equivalent) is mined in Germany, most of the remainder being produced in Czechoslovakia, the Soviet Union, and Hungary.[2] Over half the German output is manufactured into briquettes, thereby reducing the moisture and doubling the heating value per cubic foot. These briquettes are used for household and factory fuel. Lignite is also an important raw material in the German chemical industries, which recover oil, tar, gas, and wax as by-products of distillation.

A slightly higher type of coal than brown lignite is *subbituminous* coal, or black lignite, which is sometimes used for heating homes and occasionally as fuel for locomotives and other steam engines.

At the other extreme from lignite is *anthracite,* the hardest of coals, which is usually found where folding and warping of the earth's crust provided the greatest pressure in coal formation (see Fig. 304). As Figure 285 indicates, this brilliant black coal has a carbon content of about 95% and very little moisture and volatile matter. In contrast with lignite, it does not ignite easily, but it holds it fire well, gives off great heat with almost no smoke or gas, and leaves very little ash. These qualities make anthracite an ideal household fuel, which is its principal use. Of the world's output of anthracite, nearly one half is mined in the Soviet Union, more than one fourth in the United States, and most of the remainder is produced in Belgium, Great Britain, Germany, and Indochina.

A slightly lower type of coal is *semianthracite,* which is used for domestic heating and

[2] About 4½ tons of German lignite are considered to be the equivalent of 1 ton of bituminous coal; in Czechoslovakia the ratio of lignite to coal is 1.7 to 1; in Hungary, the United States, and most other countries the ratio is 3 to 1.



See war and depression. Bituminous coal mines compete with oil and each other. *U. S. Minerals Yearbook, 1952*

also as fuel for steam engines and other industrial uses.

Between the extremes of lignitic and anthracitic coals is a broad class or group of *bituminous* coals that vary greatly in moisture, volatile matter, and fixed carbon content and which consequently possess a wide diversity of use.[3] Thus, low-volatile bituminous coals are preferred as bunker coal for steamships, since they contain little moisture and volatile matter and rank highest in heating value per ton, such features being desirable aboard ship where all available space is needed for cargo. On the other hand, the high—volatile coals are obviously the best for the production of artificial gas, and some of them can be used in the manufacture of coke, the volatile matter yielding many by-products. Four countries usually produce over 70% of the world's output of bituminous coal, namely, the United States, the Soviet Union, Great Britain, and Germany—the American share being over one fourth of the world's total output. If the tonnage of lignite be reduced to its bituminous coal equivalent, it is interesting to note that of the world's total production of coal in 1950 about 85% was bituminous, 9% was anthracite, and 6% was lignite.

A fundamental resource. The importance of coal in the world of today can scarcely be overemphasized, for as one authority observes, "Of all the resources which are basal to our existing civilization, the possession and utilization of coal must be placed first."[4] As we have seen, it is the possession and use of inanimate energy that so greatly increases the productivity of human labor and places so much wealth and political power in the hands of a few nations. In spite of the spectacular development of petroleum and other fuels in recent decades, coal remains the world's prime source of energy (see Table 17:1).

Although declining in relative importance, coal continues to provide more than half the world's inanimate energy supply.[5] The output of fuel and power from all types of coal is more than double that obtained from petroleum, five times that of natural gas, and eight times that of water power. It is probably six or seven times greater than the amount obtained from firewood and peat. During the course of a year, the energy of coal is six times greater than the muscular force of all the men and draft animals in the world. Fully one half the world's annual output of work is now accomplished by the use of coal (see Tables 2:2 and 17:1).

Coal remains of paramount importance to the great industrial nations of Europe. It is the source of more than 90% of all fuel and power produced in Great Britain, Germany, Belgium-Luxembourg, and Czechoslovakia. It is by far the leading source of inanimate energy in

[3] For a description of the characteristics and uses of the principal types of coal, see International Labour Office, *The World Coal-Mining Industry,* League of Nations, Geneva, 1938, Vol. 1, pp. 18–24, and H. M. Hoar, *The Coal Industry of the World,* U. S. Dept. of Commerce, Washington, 1930, pp. 8–13, 298–301.

[4] Edward Charles Jeffrey, *Coal and Civilization,* The Macmillan Co., New York, 1925, p. 2. See also Erich W. Zimmermann, *World Resources and Industries,* rev. ed., Harper & Brothers, New York, 1951, pp. 454–469.

[5] *Cf.* U. S. Dept. of State, *Energy Resources of the World,* Washington, 1949, p. 28; Zimmermann, *op. cit.,* p. 454; and International Labour Office, *op. cit.,* p. 32.

TABLE 17:1. World Output of Energy Supply from Mineral Fuels and Water Power, 1913–52

Year	Coal and lignite	Petro-leum	Natural gas	Water power	Total
	Millions of metric tons of equivalent coal				
1913	1259	70	24	86	1439
1929	1412	276	76	100	1864
1937	1404	381	104	124	2013
1952	1688	830	320	277	3075
	Percentages of total supply				
1913	87.5	4.9	1.7	5.9	100
1929	75.7	14.8	4.1	5.4	100
1937	69.7	18.9	5.2	6.2	100
1952	54.9	27.0	10.4	7.7	100

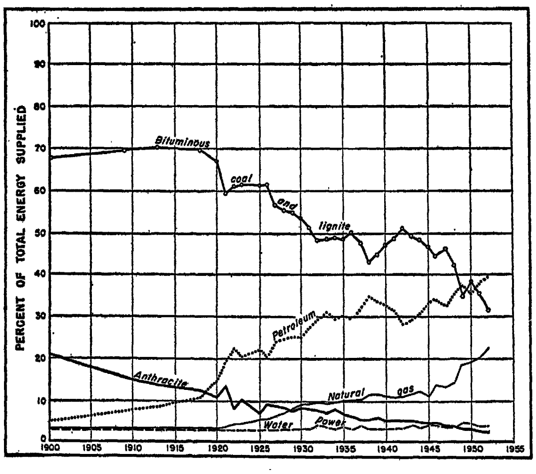
Source: Nathaniel B. Guyol, Statistical Office, United Nations, New York.

France, Poland, and the Soviet Union. In coal-poor Italy, however, less than one fourth of all fuel and power is produced from imported coal, most of the remainder being derived from water power.

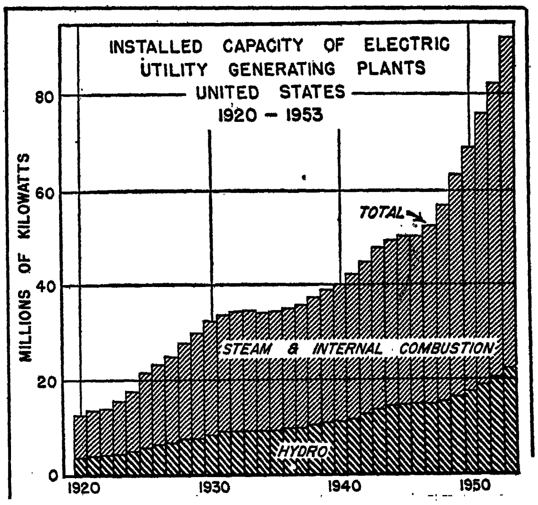
Competition of oil. In recent years no nation has witnessed such an important revolution in its energy pattern as the United States. The rapid development of huge petroleum and natural-gas resources in this country has caused a drastic decline in the relative importance of coal (Fig. 287 left). In terms of heat units, coal accounted for 88.9% of our total supply of energy from mineral fuels and water power in 1900, 69.3% in 1925, and 51.4% in 1939. In 1952 King Coal was dethroned, petroleum contributing 39.4% of our inanimate energy supply, as compared with 34% from coal, 22.5% from natural gas, and 4.1% from water power.

The United States, the Soviet Union, Great Britain, Germany, and France are the industrial leaders today. Together they consume about three fourths of the world's annual supply of coal. With the exception of the Soviet Union, the principal manufacturing districts in each of these countries have easy access to excellent coal fields. These areas are the big centers of fuel and power production, iron and steel manufacture, metal fabrication, chemical manufacture, and other heavy industries. In and around these districts are a host of auxiliary industries. A continuous procession of foodstuffs and raw materials, including most of the world's petroleum, moves to the great urban and industrial areas that have grown up around coal. Coal is the attracting magnet. British cities are wonderful examples of this.

Coal is the basis of our modern machine civilization, because of its suitability for raising steam, smelting ores, and providing heat. Fully three fifths of the world's annual output of coal is used in manufacturing establishments, including gas and electric power



In this graph of U. S. per cent of total energy supplied, we see the source of coal miners' woe. ***U. S. Geological Survey, Coal Resources of the U. S., 1953***



Astounding growth. Why does hydro lag? ***U. S. Statistical Abstract, 1953***

plants.[6] Nearly one fourth of all coal is used to heat homes, offices, and other buildings. Whereas about two thirds of the world's petroleum is used for transportation, less than 15% of all coal is so used today. The world continues to depend upon coal for most of its heat, light, and power.

2. BRITISH COAL PRODUCTION AND TRADE

Early use. While it is generally believed that coal was dug up and burned as fuel by the ancient Britons before the Roman conquest, it is definitely known that during the thirteenth century coal was commonly used in manufacturing in Great Britain by brewers and smiths. At that time substantial shipments were carried by sailing vessels from Newcastle to London, where part was consumed in the city and part was reshipped to the continent.[7]

The first great impetus to British coal mining came in 1709 with the discovery of a practical method of using coal in the smelting and manufacture of iron, a development that liberated forges and foundries from dependence upon the waning supply of wood and charcoal. Thus, Great Britain was already a user of coal before the steam engine was invented. The perfection of the steam engine in 1769 proved to be a second and tremendous stimulus to the coal industry, for it was then possible to pump water out of the mines and to increase their depth, thereby increasing the supply of coal and reducing its cost. With the advent of the steamship and the locomotive, transportation costs were reduced, and the market for coal was greatly increased both inland and overseas. By cheapening coal, the steam engine cheapened energy and everything produced by power-driven machines.

Britain's early advantage. Great Britain, above all countries, was ripe for the coming of the Mechanical Revolution and the factory system. Insularity had long rendered Britain free from invasion. Government, industry, commerce, and finance had grown strong. In contrast with continental countries, serfdom had disappeared by the end of the sixteenth century. In Britain labor was intelligent and free. The old monopolistic guild system had given way to the freedom of the domestic system, and manufacturing was scattered in small workshops and homes. Domestic trade was free of local tariff barriers. Business was subject to few governmental restrictions. Capital had accumulated from foreign trade and was available for investment in factories and machines. The indispensable deposits of coal and iron were located close together.

In the long era of peace that followed the Napoleonic wars, many factories were built and equipped with the new machines driven by steam. Many thousands of workers left home or village workshop and farm to take factory jobs in the cities. As factories multiplied and urban population increased, handicraft manufacture disappeared and agriculture declined after the coming of free trade. Coal and steam made Britain the most urbanized and industrialized nation in the world. "Steam is an Englishman" came to be a nineteenth-century adage.

Leading British coal fields. More than three fourths of Britain's coal comes from mines in the Midlands, along the northeast coast, in South Wales, and in Scotland between the firths of Clyde and Forth (Fig. 289). The remaining coal production occurs principally in Lancashire and Staffordshire. British coal fields are distinguished by the quality and variety of their bituminous coals, anthracite amounting to less than 3% of the total output. Great Britain has long led the world in the mining of gas coals, the coals of Durham being used not only in British gas works but also by many gas works in Germany, France, and other continental countries. Likewise, the coking coals of South Wales and

[6] In the United States between 15% and 20% of all coal is converted into electricity, as compared with 2% of the petroleum, 10% of the natural gas, and practically all the water power.

[7] Isador Lubin, "Coal Industry," *Encyclopaedia of the Social Sciences,* The Macmillan Co., New York, Vol. 3, 1930, p. 582.

of many railroads and other coal-consuming industries in the vast British Empire and in foreign lands. On land and on sea, this was an era of coal and steam. This was Britain's Golden Age.

The decline of coal exports. After World War I, British coal exports suffered a drastic decline, decreasing from an all-time peak of 79½ million tons in 1923 to 40 millions in 1938, and to about 14 millions in 1953. The causes were serious. (1) Increasing competition from other coal-exporting countries caused the sale of British coal to decrease in one market after another. Scarcely a cargo of British coal was sold east of Suez because of competition from South African, Australian,

TABLE 17:2. British Coal Output, Exports, and Bunker Shipments, 1913–52
(millions of long tons)

Year	Output	Exports	Bunker shipments[a]
1913	287.4	73.4	21.0
1923	276.0	79.5	18.2
1933	207.1	39.1	13.5
1943	198.9	3.6	3.2
1953	223.5	14.0	2.8

a Bunkers shipped at U. K. ports for the use of vessels engaged in foreign trade.
Source: Chamber of Shipping of the United Kingdom, *Annual Reports.*

and Japanese coal. Much less British coal was sold in the big European markets because of growing competition from German, Polish, and Russian coal. (2) Coal encountered competition from other fuels both on land and at sea. Many countries found it cheaper to use petroleum or water power, as happened along the west coast of North and South America. Today over 80% of the world's ocean-going merchant vessels use oil as fuel, as compared with less than 3% in 1913, resulting in a great decline in shipments of bunker coal (see Table 17:2). (3) Increasing improvements in marine engines, locomotives, blast furnaces, electric-power plants, and heating units reduced the need for coal. (4) Increasing costs and greater difficulties in mining seriously impaired Britain's ability to export.

In the reconstruction era following World War II, Great Britain was unable to meet foreign demands for coal. Europe and South America turned to the United States to meet their needs. In 1951 France, West Germany, Italy, the Netherlands, and other European countries purchased some 30 million tons of coal from the United States and about 10 million tons from Poland. Even Great Britain was compelled to import 1½ tons of American coal. "Carrying coals to Newcastle" no longer was a symbol of economic folly but a signal of dire distress.

The crisis in production. The long downward trend in British coal exports has been accompanied by decreasing production, and the daily output per miner is indeed low (see Tables 17:2 and 17:3).

In Great Britain centuries of mining have exhausted the more accessible coal seams. Less than 10% of British coal is mined at the surface. Many mines are 2000 feet deep, and others go down 3500 feet. Costs have increased with depth. Many seams are thin and faulted and cannot be worked by machines, but in many mines there apparently is little reason for the continued use of antiquated methods of cutting, loading, and hauling coal. Labor unions are well entrenched. High wages fail to attract young men to the mines, as underground coal mining is dangerous, dirty, and dull. Between 1927 and 1950 employment dropped from 1,000,000 to 687,000 men.

The impending crisis in the coal industry led a Conservative government in 1938 to make coal resources the property of the nation, effective in 1942, and nationalization of the industry was completed by a Labour government in 1945. In postwar years the coal shortage became so acute that the National Coal Board imposed restrictions on the use of coal. At times factories operated on a part-time basis, and in winter the British people shivered with cold.[8]

In 1950 the National Coal Board announced a 15-year plan for opening 70 new mines,

[8] See L. Dudley Stamp, "Britain's Coal Crisis," *The Geographical Review*, April 1948, pp. 179–193.

scrapping many old mines, and modernizing methods of production. This plan to raise Britain's coal output by 40 million tons will cost British taxpayers $1,778 million. Drastic surgery is needed for the ailing coal industry.[9] The alternative is further decline.

3. THE UNITED STATES COAL INDUSTRY

Late and rapid development of U. S. coal mining. During the first two thirds of the nineteenth century, while Great Britain was busy manufacturing with coal, the people of the United States were chiefly employed in farming and settling the free lands of the Mississippi valley, which the United States government was giving away to settlers who rarely needed coal for the family stove. Our manufacturing industries started, before the improvement of the steam engine, in New England where many streams tumbling down from the highlands made abundant waterfalls and good water power. For domestic fuel the American people for two centuries burned wood, while Britain, old and relatively populous, had been short of forests in Queen Elizabeth's time and was using coal. In 1660 the British consumption was ⅖ ton per capita, a quantity not equaled in the United States until after 1850.

In the first decade of the nineteenth century only a few thousand tons of coal were mined in the United States each year, in contrast with an annual output of about 10 million tons in Great Britain and 5 million tons in Belgium.[10] Indeed, in 1822 American coal production consisted of 54,000 tons of bituminous coal mined near Richmond, Va., and boated down the James River. In that year Pennsylvania produced 4600 tons of anthracite in the Schuylkill Valley near Philadelphia. Not until 1837 did the nation's coal production reach 1 million tons. By 1850 it had grown to 7 million tons, or about one eighth of the British output.

The advent of the steamboat and locomotive in the early decades of the nineteenth century marked the beginning of a new era in travel and trade. In 1814 a steamboat made the first successful trip upstream on the Mississippi River, and two years later steam navigation was inaugurated on the Great Lakes. New Orleans had over 1000 steamboat arrivals in 1835, the number increasing to more than 3500 by 1850.[11] Between 1830 and 1850 U. S. railroads increased in length from 23 to 9021 miles. Land transport boomed. Thus the steam-driven locomotive broke the shackles that for ages held most of mankind close to the river bank and seashore.

In 1850 about 94% of the people in the United States lived east of the Mississippi, and not a single mile of railroad had been built west of the river. It was coal and steam that enabled the American people to complete the settlement of the West, and by 1900 a railway network of 193,000 miles covered the nation. Furthermore, the rapid development of our railroads, together with steam navigation on our coastal and inland waterways, made possible the economical and large-scale movement of coal. Coal drove the steam engine. Thus it hoisted itself to the surface of the earth, and also hauled itself to market.

1880 marks a turn. The remarkable expansion of transportation, mining, steel manufacturing, and other industries after 1880 greatly increased the demand for coal. Furthermore, labor-saving devices in the coal mines helped to speed up production. By the end of the century the cutting machine had replaced the miner's pick in the production of 25% of the nation's coal. In 1899 the United States, with an output of 254 million tons, became the largest coal producer in the world.

[9] The chairman of the National Coal Board declared that mining coal in Britain was like running up a down escalator. You have to run hard to stay where you are. You have got to make superhuman efforts to advance. "Up & Down the Escalator," *Time*, November 27, 1950, p. 32.

[10] *Cf.* Lubin, *op. cit.*, p. 583; U. S. Bureau of the Census, *Historical Statistics of the United States, 1789–1945*, Washington, 1949, p. 142; and Bituminous Coal Institute, *1953 Bituminous Coal Annual*, Washington, 1953, pp. 72–73.

[11] Marvin L. Fair and Ernest W. Williams, Jr., *Economics of Transportation*, Harper & Brothers, New York, 1950, p. 35.

The United States has maintained leadership in coal production throughout the present century, with the single exception of 1938 when Nazi Germany surpassed us. Among the advantages contributing to American leadership were the growing demand for fuel, easy access to huge coal deposits, the availability of thick and generally level coal seams in our large bituminous fields, the increasing importance of surface mining, and the widespread use of labor-saving machines. In view of such advantages, it is not surprising that the U. S. coal miner is the most productive in the world (see Table 17:3).

TABLE 17:3. Daily Output of Coal per Man in American and European Mines
(short tons)

Country	1929	1939	1949
United States[a]			
bituminous	5.42	5.50	6.62[b]
anthracite	2.64	3.28	2.71[c]
Belgium	0.92	1.23	1.02
Czechoslovakia	1.45	1.54	1.60[c]
France	1.08	1.40	1.20
Germany (Ruhr)	1.72	2.28	1.52
Netherlands	1.89	2.62	1.91
Poland	2.07	2.99[d]	2.02[e]
Saar	[f]	1.83	1.45
United Kingdom	1.54	1.67	1.72

a Data for the United States relate to man-days worked. Data for other countries relate to man-shifts worked.
b Average for the bituminous industry. The output per man-day in surface mines was 15.33 tons; in underground mines, 5.42 tons.
c Data as of 1948.
d Data as of 1937.
e Present territory.
f Not available.
Source: Bituminous Coal Institute, *1951 Bituminous Coal Annual*, Washington, 1951, pp. 159–160.

We Americans admit that we are smart, but this table suggests that we may sometimes overadmit. Gratitude might be a more suitable emotion—gratitude for the ability to stick a railroad into a hillside and haul out that marvelous bituminous coal. *We* didn't make it. We waste it.

Approximately 32 billion tons of coal have been mined in the United States to date. Wartime demands caused record outputs of 678 million tons in 1918 and 683 millions in 1944, and in 1947 production reached an all-time peak of 688 million tons. In 1953 bituminous coal production amounted to 454 million tons; anthracite, 31 million; and lignite, 3 million. However, the American coal-mining industry is not without its problems, notably high freight rates, rising labor costs, unpredictable work stoppages, and serious competition from other fuels. The per-capita output of coal in this country has declined from 6½ tons in 1918 to less than 4 tons at the present time.

The eastern Pennsylvania anthracite field. The first coal field to be developed exclusively in response to the steam demand was the anthracite field of eastern Pennsylvania, which has the best coal in America and is also nearest to the cities of the Atlantic seaboard. A canal built up the Schuylkill from Philadelphia to this field was followed by some of the earliest railroads. Every railroad system anywhere near this coal has reached out a branch for a share of the coal freight until now a dozen railroads carry this coal in all directions. About 80% of all anthracite is now sold to New York, Pennsylvania, New Jersey, and the New England states. About 10% of the output is destined for Canada. The United States has a production of only 3/10 ton of this valuable coal per capita per year, all produced in the small coal region of eastern Pennsylvania. These fields cover an area of only 480 square miles, with the cities of Scranton, Wilkes-Barre, Pottsville, and Shamokin being the chief mining centers.

While the output of anthracite was about the same as that of bituminous coal in 1870, from that time on the relative importance of anthracite declined. By 1900 the tonnage of bituminous coal was four times that of anthracite, and in 1953 the ratio was nearly 15 to 1. From a peak production of 89 million tons in 1917, the output of anthracite declined to 31 million tons in 1953.

Less than two thirds of Pennsylvania anthracite is now obtained from underground mines, where mechanization is difficult because of thin and folded coal seams. Indeed, less than one half of the underground production is loaded mechanically, and less than 1 million tons are mined with cutting machines. Approximately one fourth of all Pennsylvania

anthracite is now derived from surface or strip mines; about one tenth is reclaimed from culm banks left by the mining operators of past decades; while dredges recover nearly 1 million tons a year from rivers and creeks.

It is doubtful if our anthracite reserves will last a century at the present rate of use. What is happening is that we are starting with the high ranks of coal and working down, skimming the cream of our natural resources as we have always done!

The Appalachian bituminous coal fields. The Appalachian bituminous coal field, which reaches almost without a break from northern Pennsylvania into northern Alabama, contains the finest bituminous coal lands in the world. The coal area in western Pennsylvania alone is larger than Massachusetts, Rhode Island, and Delaware combined. Ohio River navigation opened this rich fuel deposit to the world and caused many new towns to spring up in the wilderness to shelter the miners. Pittsburgh, standing where the navigable Ohio is formed by two navigable branches, was the most convenient point of access to this coal field and the natural place for its earliest development. Each year acres and acres of barges of Pennsylvania coal float down the Allegheny, the Monongahela, the Ohio, and the Mississippi, carrying millions of tons to Pittsburgh, Cincinnati, New Orleans, and other cities along the great waterway (see Fig. 275).

The central part of this Appalachian coal field in West Virginia, eastern Kentucky, Tennessee, and part of Virginia was not developed so early because it was more difficult of access, but many mines were opened there after 1915. At the present time there are in eastern Kentucky 10,000 square miles of this Allegheny plateau underlaid with coal. But this plateau has been carved by its many streams into a succession of steep mountains and sharp gorges, which are so difficult to travel that in much of it there is no railroad, and therefore no commercial coal mining.

As a consequence of keen competition from newer fields to the south, Pennsylvania's output of bituminous coal has declined.[12] Since 1931 West Virginia has led the Union in the production of bituminous coal. Numerous railway spurs have been pushed back into narrow valleys to bring out the coal, and many conveyor belts and overhead conveyor systems are now used. The canalized Kanawha River, like the Monongahela and Allegheny, carries much coal. Some of the Appalachian valleys are so narrow that the houses of the mining towns are perched row after row upon the steep slopes that rise directly from the streams.

The southernmost of these eastern coal fields is in Alabama near Birmingham. It is very accessible to adjacent markets and hence has greater development than any field south of Kentucky. This coal field and the nearby deposits of iron ore and limestone are the basis of Birmingham's steel industry.

The eastern interior field. Southern Illinois, southern Indiana, and western Kentucky constitute a coal field that is second in importance only to that at the headwaters of the Ohio. The coal, bituminous, is not as good quality as that of the Appalachian fields, but it is better than most of the coal of Europe, and its nearness to Chicago, St. Louis, and the manufacturing centers of Illinois and Indiana makes it the chief dependence of this region. Good coking coal is now mined in southern Illinois, which is of great importance to the iron and steel plants at Gary and other midwestern cities. In 1953 the output of bituminous coal in Illinois, Indiana, and western Kentucky was about 83 million tons, or 18% of the nation's total bituminous output.

The western coal fields. It is an interesting fact that the quality of our coal declines as we go west until we reach the Rocky Mountains. West of the Mississippi and remote from the major centers of population are extensive coal fields with vast quantities of lignite, subbituminous, and generally low-grade bituminous coals (see Fig. 271 top). In the

[12] See Raymond E. Murphy and Hugh E. Spittal, "Movements in the Center of Coal Mining in the Appalachian Plateaus," *The Geographical Review,* October 1945, pp. 624–633.

aggregate, these fields possess about two thirds of our total reserves, but they produce only 8% of the nation's coal.

In the western interior and southwestern fields extending from central Iowa to central Texas are beds of bituminous coal that outcrop along the eastern margin, where small quantities are mined for local consumption. The Rocky Mountain states produce little coal. The chief industrial users of coal are the steel plants of Provo, Utah, and Pueblo, Colo. The states of Utah and Colorado, with annual outputs of about 6 million and 4 million tons respectively, are the leading bituminous coal producers west of the Mississippi River.

In terms of a bituminous coal equivalent, the vast lignite and subbituminous coal deposits of the Great Plains and Rocky Mountains are the largest recoverable coal reserves in this country. Perhaps some day they will be processed into synthetic oil and gasoline or will be converted into gas to be piped to distant markets.

Mining machinery. No coal-mining industry in the world approaches our bituminous industry in the use of power-driven machinery and in daily output of coal per man (see Table 17:3). Between 1914 and 1953 the output of surface mines increased from 1 to 103 million tons, nearly all of which was dug and handled by power shovels, draglines, and other machines. Underground mines, averaging only 190 feet in depth, in 1953 produced 77% of our bituminous coal. Since coal seams east of the Mississippi average 5½ feet in thickness, they are easily worked by machines—loading machines, electric trucks, conveyor belts, and electrified underground railroads. In underground mines over 95% of all coal is cut by machines, and 79% is loaded mechanically (see Fig. 302 bottom).

Coal as freight. The transportation of bituminous coal from more than 8000 mines to market is perhaps the largest moving job in the world. Bituminous coal is a $1-billion-a-year traffic for U. S. railroads, providing more than one fourth of their revenue tonnage and over one eighth of their total freight revenue. In 1953 about 700,000 gondola and hopper cars were used to move 362 million tons of bituminous coal. Of the coal shipped out of the mining areas in 1953, 81.4% moved by rail, 10.6% was carried by truck, and 8.0% moved by water.[18]

The average rail haul for bituminous coal in the United States is about 300 miles, which more than doubles the cost of the coal by the time it reaches the market. High railway rates for short hauls have led to a great increase in the use of motor trucks for delivering coal up to 100 miles and more. Indeed, about 50 million tons of coal are shipped from mine to market in trucks each year. Wherever possible, coal is shipped by water, and about 27 million tons originating at river mines are shipped by barge directly to destination.

The decline of coal production in Great Britain and other European countries during World War II and its slow recovery in postwar years resulted in a large increase in coal exports from the United States to European and other overseas markets. In 1953 our coal exports amounted to 37 million tons, as compared with 62½ millions in 1951, an all-time peak of 86 millions in 1947, and only 12 millions annually in 1937–39. In prewar years nearly all our coal exports were destined for Canada. In recent years more than one half of our shipments have been made to European and other overseas markets, bituminous coal accounting for nearly 90% of our total exports. In the future it is not likely that such large quantities of high-priced American coal will be shipped abroad.

4. CANADIAN, ALASKAN, AND LATIN AMERICAN COAL

Canadian coal production and imports. Canada, with large coal reserves, produced about 13 million tons of bituminous and subbituminous coal in 1953, or about 40% of her domestic requirements. The most populous and most highly industrialized parts of Canada in southern Ontario and the St. Lawrence Val-

[18] U. S. Bureau of Mines, *Weekly Coal Report,* October 22, 1954, p. 7.

ley are without coal and hence must rely upon imported coal and local water power. In 1952 Canada imported about 24 million tons of coal by rail and across the Great Lakes from the United States.

Along the coast of Cape Breton Island near Sydney is a coal field with thick seams of high-grade bituminous coal, some of which is mined under the sea. Water transportation enables the coal to be marketed in the St. Lawrence Valley as far west as Montreal and also in New England. Nova Scotian coal and Newfoundland iron ore meet at Sydney, where iron and steel are manufactured.

The vast lignite fields of North Dakota and Montana are continued in Manitoba and Saskatchewan, where about 2 million tons a year are mined for local use. In southern Alberta and southeastern British Columbia are subbituminous and bituminous fields that have long supplied local needs and also locomotive fuel for the transcontinental railroads. On the Pacific coast the low-grade bituminous coals of Vancouver Island were once important as bunker fuel for steamers but are now mined chiefly for local consumption. As a result of the new oil boom in Alberta, it is likely that the use of coal will decline in Canada's prairie provinces.

Alaskan coal. The Territory of Alaska is endowed with a variety of coals ranging in rank from lignite to anthracite. Coal beds are known to exist along the seacoast and in the interior, with reserves estimated from 20 to 107 billion metric tons. The Alaska Railroad serves mines in the Tanana and Matanuska valleys which account for nearly all of Alaska's output of 500,000 tons of bituminous coal a year. Unfortunately, most Alaskan coal is too inaccessible for use elsewhere at the present time.

The limited coal resources of Latin America. With about 16% of the world's land area and nearly 7% of the world's population, Latin America has only 1% of the coal reserves, and its mines produce only $^{3}/_{10}$ of 1% of the world's coal. Brazil at present leads all Latin American nations with an annual output of about 2 million metric tons of low-grade bituminous coal. Most of this coal is mined near Tubarão in Santa Catarina and at São Jerônimo in Rio Grande do Sul. Much of it is shipped to Rio de Janeiro for the manufacture of power and gas, and some is used in conjunction with imported coal at the new steel plant at Volta Redonda.

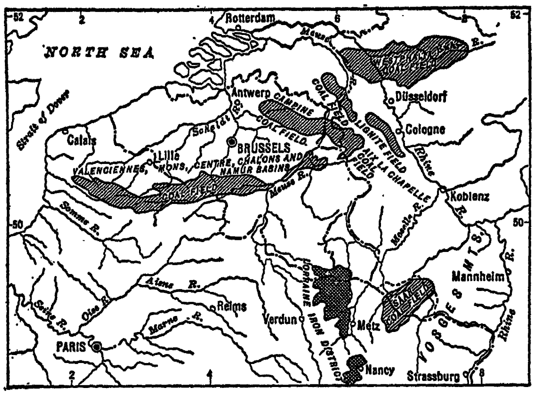
Chile produces about 2½ million metric tons of low-grade bituminous coal a year at Coronel and Lota, where the mines extend under the sea. Chilean coal is used chiefly by government-owned railroads and by the new steel plant at Huachipato. In Mexico about 1 million metric tons of fairly good bituminous coal are produced annually near Sabinas and Lampazos in northern Coahuila, most of it being shipped to the iron and steel centers of Monterrey and Monclova. Colombia's output of 1 million tons is mined near Medellín and Bogotá, where it is used by small manufacturing enterprises. Peru mines about 200,000 tons for use in her mining industry.

5. COAL IN WESTERN EUROPE

Germany. In western Germany the Westphalian coal field is the largest coal deposit in Europe (see Fig. 296). The seams of this field vary from 5 to 30 feet in thickness; they are worked by efficient methods; and they yield high-grade coking, steam, and gas coals. In normal times large quantities of Westphalian coal move by train, canal boat, and Rhine River barge to the great markets of Germany and adjacent countries. Across the French border is the huge iron deposit of Lorraine. No other coal field on the continent has such a ~~favorable location~~.

Within the Westphalian field is the famous Ruhr Valley with its heavy industry. In 1937 the Ruhr district produced 128 million metric tons of coal, or three times as much as all France and more than the entire Soviet Union. Indeed, the power equivalent of Ruhr coal exceeded the power produced by all the hydroelectric stations in the world.[14]

[14] See Chauncy D. Harris, "The Ruhr Coal-Mining District," *Geographical Review*, April 1946, pp. 194–221, and Norman J. G. Pounds, *The Ruhr*, Indiana University Press, Bloomington, 1952.



Coal fields of France, Belgium, the Netherlands, the lower Rhine, and the Saar. France, Belgium, and Germany share one coal field, close to the sea, the Rhine, and the Lorraine ore district. ***U. S. Geological Survey***

Of Germany's prewar output of coal, about 70% was mined in the Ruhr district, 17% in Silesia, and 7½% in the Saar Basin, the remainder being obtained chiefly from the coalfields of Saxony and Aachen.[15] In the postwar era Silesia has become a part of Poland, and the coal of the Saar has been delivered to France.[16]

Germany is not only well endowed with bituminous coal, but her Westphalian field yields about 5 or 6 million tons of anthracite a year. Important deposits of lignite in Saxony, in the Cologne district, and east of the Elbe yield about 200 million tons annually, the largest lignite production in the world. No other country approaches Germany in the use of lignite in electrical, chemical, and other industries, located chiefly in mining areas.

In 1953 Germany, excluding the Saar, produced only 130 million metric tons of coal, as compared with 175 millions in 1939. These facts reveal the havoc wrought by the war—the damage to railroads, canals, and mining areas, the shortage of food and homes, the loss of territory, the division of the nation into two uncooperative units, and the general breakdown in economic organization. West German production in 1953 amounted to 126 million tons.

France, Belgium, and Holland. Not far from the North Sea is the Sambre-Meuse coal field, which extends from the French provinces of Pas-de-Calais and Nord across southern and eastern Belgium into Germany near Aachen, with a small outlier in the southern tip of Holland (see Fig. 296). This field makes Belgium almost self-sufficient in coal and is the chief source of supply for France and Holland.

The coal seams of the Sambre-Meuse field are thin and faulted. Many mines are old. Shafts are deep, costs are high, and there is little prospect of any substantial increase in production. While the coal of this field is good for making steam, heat, and gas, it must be mixed with higher grade imported coals in order to manufacture coke.

In 1950–53 the French coal output averaged 53 million metric tons, as compared with 49 millions in 1939, but the dire need of coal and the dwindling of British supplies made it necessary for France to obtain coal from the United States and Poland as well as from the nearby Ruhr and Saar.[17]

Poland and Czechoslovakia. On two occasions Germany's loss was Poland's gain. After World War I Germany's rich Upper Silesian coal field was divided among Poland, Germany, and Czechoslovakia, with Poland receiving the largest share. In the 1930's approximately three fourths of all Polish coal was mined in Upper Silesia and the remainder came from the Dombrova Basin and Cracow. In 1936–38 production averaged 35 million metric tons a year, and a third of Polish coal was exported to the coal-poor countries along the Baltic Sea.

---

[15] International Labour Office, *op. cit.*, p. 59.

[16] Following the Potsdam Conference in 1945, the Saarland was assigned to France as part of her zone of occupation. On January 1, 1951, the Saarland achieved de facto political autonomy, a tentative status that may be confirmed, modified, or canceled by a treaty with Germany. See Colbert C. Held, "The New Saarland," *Geographical Review,* October 1951, pp. 590–605.

[17] In 1951 France imported 5½ million short tons of coal from the United States. According to one report, France spent three fourths of every dollar of U. S. aid on the purchase of American coal. "Coal Is the Tyrant," *Time,* January 14, 1952, p. 27.

After World War II the remaining German coal fields in Upper and Lower Silesia were taken over by Poland. In 1950–53 Polish mines yielded about 83 million tons a year. With exports of 31 million tons in 1950, Poland was Europe's leading exporter of coal. In contrast with Poland, Czechoslovakia gained no coal fields from her neighbors, and her postwar production of bituminous coal remains at about its prewar level.

With the exception of the Ruhr, the Upper Silesian coal field is the largest field in western Europe. Efficient methods are used in mining coal seams that vary from 3 to 30 feet in thickness. Before and since World War II, the daily output of coal per man in Poland has been the highest in Europe (see Table 17:3).

6. THE COAL RESOURCES OF THE SOVIET UNION

The size and significance of U. S. S. R. coal reserves. The Soviet Union is lavishly endowed with anthracite and bituminous coal, lignite, and peat. Its anthracite reserves are the largest in the world. Its bituminous coal supply ranks second only to that of the United States. Its lignite is surpassed only by U. S. and Canadian reserves. No other nation has so much peat.

The total coal reserves of the Soviet Union are estimated as 1200 billion metric tons, or about 24% of the world's coal, as compared with 34½% for the United States (see Table 17:4).[18] Bituminous coal accounts for fully 85% of Russian reserves. The Soviet Union also ranks second in coal production (see Fig. 300). Coal production, including unknown amounts of lignite, increased from 145 to 320 million metric tons between 1939 and 1953. These startling figures give a measure of the success of the Russian effort to increase mining and manufacturing. According to many reports, it was carried out by ruthless exploitation of men and materials.

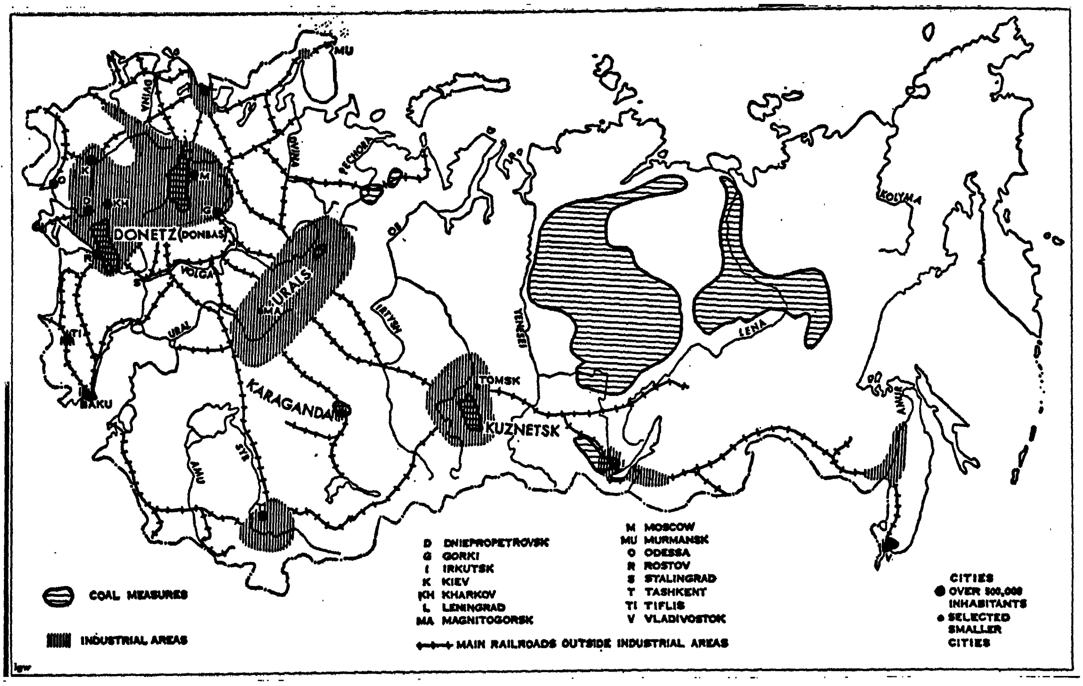
Within the Soviet Union are more than 80 coal fields, scattered from Moscow to Sakhalin and from the Arctic Circle to the Sea of Azov. The wide distribution of coal has facilitated decentralization of industry, a

TABLE 17:4. The World's Coal Reserves in 1953
(millions of metric tons)

Region and country	Anthracite; bituminous and subbituminous	Lignite and brown	Total	% of world total
Asia:				
U. S. S. R...	998,000	202,000	1,200,000	24.0
China	1,011,000	600	1,011,600	20.2
India	62,143	2,833	64,976	1.3
Japan	16,218	473	16,691	.3
Others	7,214	349	7,563	.2
Total	2,094,575	206,255	2,300,830	46.0
North America:				
United States	1,303,066	420,350	1,723,416	34.4
Alaska	22,498	74,915	97,413	2.0
Canada	65,053	24,592	89,645	1.8
Total	1,390,617	519,857	1,910,474	38.2
Europe:				
Germany ..	279,516	56,758	336,274	6.7
United Kingdom..	172,200	......	172,200	3.4
Poland	80,000	18	80,018	1.6
Czechoslovakia ..	6,450	12,500	18,950	.4
France	11,224	125	11,349	.2
Portugal ...	6,036	4,200	10,236	.2
Others	16,619	14,289	30,908	.6
Total	572,045	87,890	659,935	13.1
Africa:				
Union of South Africa ...	68,014	0	68,014	1.4
Others	1,720	210	1,930	...
Total	69,734	210	69,944	1.4
Australasia:				
Australia ..	13,900	39,200	53,100	1.1
Others	57	489	546	...
Total	13,957	39,689	53,646	1.1
South and Central America:				
Colombia ...	10,000	0	10,000	.2
Chile	2,116	?	2,116	...
Others	1,617	4	1,621	...
Total	13,733	4	13,737	.2
World total ..	4,154,661	853,905	5,008,566	100.0

Source: Paul Averitt, Louise R. Berryhill, and Dorothy A. Taylor, *Coal Resources of the United States,* Circular 293, U. S. Geological Survey, Washington, October 1, 1953.

[18] If lignite be reduced to a coal equivalent, an older estimate credits the Soviet Union with 27% of the world's coal, as compared with 42% for the United States. Dept. of State, *op. cit.,* p. 52.



Soviet Union industrial areas and coal deposits. Compare other areas, water transport. ***From Renner, Durand, White, and Gibson:*** **World Economic Geography,** ***Thomas Y. Crowell Co., p. 368***

major Soviet aim. New and important industrial areas have arisen since 1930 in the Urals, Siberia, and Turkestan, remote from the danger of foreign attack. The growth of factories and cities in the agricultural and pastoral areas of Asia has resulted in a higher standard of consumption and less dependence upon European Russia for manufactured goods.

In one important respect the distribution of Soviet coal is unfortunate. About 84% of the nation's coal reserves lie hundreds of miles east of the Urals, whereas fully two thirds of the Russian people live in European Russia. Furthermore, the major deposits of iron ore are in the Urals or far to the west. Good coking coal and iron ore are seldom found near each other as in the Ukraine. No other nation has such a big problem in bringing coal and iron together for the large-scale manufacture of steel.

Principal European coal field. The Donets Basin, or Donbas, is by far the most important coal-producing area in the Soviet Union. This coal basin occupies about 10,000 square miles north of the Sea of Azov and extends eastward from Stalino through the southeastern Ukraine to the Don River. High-grade bituminous coal, including much coking coal, accounts for nearly 60% of total reserves, the remainder consisting of anthracite.[19]

Although Donets coal seams are thin, folded, and faulted, the location of the basin and the quality of its coals make it the most thoroughly exploited coal field in the Soviet Union. It is the only large deposit of good coal in European Russia and supplies most industrial and railway needs west of the Urals. Within a radius of 200 miles are the chief materials for steel making—the iron ore of Krivoï Rog and the Kerch Peninsula, the manganese of Nikopol', and Donets coal and limestone. It is not surprising that one of the

[19] Donets coal reserves are estimated at 60 to 90 billion metric tons. Ernest C. Ropes, "Donets Basin," *Foreign Commerce Weekly,* October 30, 1943, p. 3.

world's great centers of heavy industry has developed in and around the Donets Basin.

Principal Siberian coal fields. The second major coal-producing area is the Kuznetsk Basin, or Kuzbas, in the Kemerovo-Stalinsk region of south central Siberia. This is one of the world's largest deposits of high-grade coal. Reserves are estimated at 450 billion metric tons, including 54 billion tons of anthracite and large amounts of excellent coking coal.[20]

When the first blast furnaces and steel plants were established in the Kuznetsk Basin and at Magnitogorsk in the southern Urals, westbound trains carried Kuznetsk coal and returned with Ural iron ore, a rail haul of 1417 miles. This long movement of coal and iron was greatly reduced a few years later by the discovery of iron ore at Temir-Tau near Stalinsk and by the development of the Karaganda coal field some 600 miles southeast of the Urals. The Karaganda Basin has reserves estimated at 50 billion metric tons and has come to rank third among the nation's coal-producing regions. It supplies coking coal for the great metallurgical industries of the Urals and fuel for the railroads and factories of Kazakhstan.

The other coal fields. Coal is now being mined on the edge of the Caucasus and the Pamirs, in the upper Yenisei and Lena valleys, the Lake Baikal area, the Bureya section of the Amur Valley, at Artem and Suchan near Vladivostok, and on the island of Sakhalin. While the present output of these coal fields is much smaller than that of the Donets, Kuznetsk, and Karaganda basins, it is of growing importance to the widely scattered industries of Asiatic Russia and to the far-flung Soviet railway system. Sheer distance has long been a national handicap, and more than one fourth of the U. S. S. R. coal output is consumed each year as locomotive fuel.

Although many new coal fields have been developed under the Soviet regime, some of the leading industrial districts remain dependent upon distant coal supplies. The Leningrad and Moscow-Gorki districts make intensive use of local peat and lignite, yet both are dependent upon Donets coal; and the Leningrad area obtains some of its coal from Spitsbergen Island and the newly developed Pechora Basin near the Arctic Circle. In the southern Urals, deposits of low-grade bituminous coal at Kizel and lignite near Chelyabinsk are inadequate, and Karaganda and Kuznetsk coals continue to supply about half the needs of this great industrial district. Soviet coal transport is a heavy drain on industry.

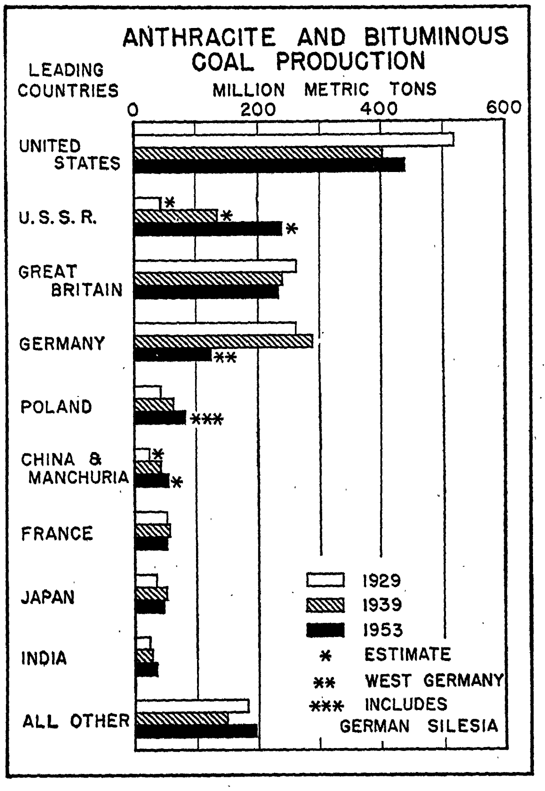
7. THE COALS OF ASIA, AUSTRALIA, AND SOUTH AFRICA

Japan. Coal mining in Japan is a long-established industry, certain beds having been worked for over 400 years. During the present century Japan has had the ambition to become a great industrial nation, and for years her government subsidized almost every important industry. As a result of intensive use of meager reserves, coal production in Japan proper increased from 21 million metric tons in 1913 to an all-time record of 57 millions in 1940.

About two thirds of Japanese coal is mined in northern Kyushu, and the remainder in Hokkaido and Honshu. Most of the coal is low-grade bituminous and subbituminous, and the lack of good coking coal has long been an obstacle to the development of metallurgical industries. In prewar years about one tenth of the coal consumed in Japan proper came from Korea, Karafuto, Formosa, northern China, and Manchuria—areas no longer under Japanese control—and also from Indochina.

In spite of the dislocation of her industries wrought by World War II, Japan continues to lead the Far East in coal production. In 1953 Japanese coal mines yielded 47 million metric tons, about the same as in prewar

[20] James S. Gregory and Donald W. Shave, *The U.S.S.R.—A Geographical Survey*, George G. Harrap & Co., Ltd., London, 1944, p. 230, and George B. Cressey, *Asia's Lands and Peoples*, McGraw-Hill Book Co., New York, 1951, p. 286.



Compare with table on page 297. *U. S. Bureau of Mines*

years. In the postwar era Japan has had to augment its domestic coal supply by imports from the United States.

China and Manchuria. Among the largest coal reserves in the world are those of China which, together with Manchurian reserves, have been estimated at amounts varying between 220 and 1011 billion metric tons.[21] This huge reserve has been scarcely touched by the Chinese, who have been farmers for more than 40 centuries. While nearly every province has some coal, almost 90% of the apparent reserve is concentrated in the Loess Highlands of Shansi, Shensi, Honan, and Kansu, in northern China. The coals are of high quality, including coking coal and large amounts of anthracite.

Coal mining is concentrated in the hands of a few large operators, and the bulk of the output comes from mines located along railway lines or near water transportation. The railroads and steamships are large consumers of coal, and considerable amounts are sold in Shanghai, Peiping, Canton, Hankow, and other large cities. In prewar years the coking coal of Kaiping was shipped to Japan.

Although Manchurian reserves, estimated at 9 to 17 billion metric tons, are much smaller than those of China proper, they contain some of the thickest coal beds in the world, the main bed at Fushun varying from 130 to 430 feet in thickness.[22] In 1941 production amounted to 20 million tons, most of the coal being mined in the Fushun field east of Mukden, the Fouhsin field north of Chinhsien, and the Penhsihu coking-coal area near the Anshan steel works. In 1953 Communist China, including Manchuria, produced about 57 million tons of coal and lignite.

India and Pakistan, and Indochina. The large Indian subcontinent, now divided into India and Pakistan, has coal reserves estimated at 23 to 65 billion metric tons, ranging in quality from lignite to anthracite.[23] Fully 90% of the annual output of about 37 million tons is mined in the provinces of Bengal, Bihar, and Orissa to the northwest and southwest of Calcutta. Most of the coal is used by the railroads, textile mills, and the gradually expanding iron and steel industry.

Indochina was the largest producer of anthracite coal in the Orient in 1939, the annual prewar output, of nearly 3 million tons being about half that of Great Britain or Belgium. About three fourths of the coal was exported to Japan, China, and France. For years the mines in Upper Tonkin were exclusively controlled by French corporations, and in recent years the coal output has greatly declined.

Australia and South Africa. Both Australia and New Zealand have enough coal for

[21] *Cf.* Table 17:4 and George B. Cressey, *China's Geographic Foundation*, McGraw-Hill Book Co., New York, 1934, p. 112.

[22] See H. Foster Bain, "Manchuria: A Key Area," *Foreign Affairs*, October 1946, p. 112.

[23] *Cf.* Table 17:4 and Kate L. Mitchell, *Industrialization of the Western Pacific*, Institute of Pacific Relations, New York, 1942, p. 276.

their own needs. Coal is found in all six states of Australia, but about 90% of the bituminous coal is mined in New South Wales, chiefly near the steel-making centers of Sydney and Port Kembla. In 1953 Australia produced 19 million tons of bituminous coal and 8 million metric tons of lignite.

The Union of South Africa is well endowed with bituminous coal, and about 28 million metric tons are mined each year in the provinces of Natal and Transvaal. Most South African coal is consumed by the railroads, electric-power plants, mines, factories, and other domestic users, less than 3 million tons being exported or sold as bunker fuel to steamships. While adjacent Southern Rhodesia has an annual output of 2½ million tons, coal production elsewhere on the African continent is very small.

8. METHODS OF MINING COAL

Surface mines. There are two main methods of getting coal out of the earth, namely, strip or open-pit mining and underground workings. In surface mines the overlying earth, or overburden, is first removed, and then the coal is excavated (see Fig. 302 top).

Open-pit or strip mining can be practiced only where the coal is relatively near the surface. In the United States the average thickness of the overburden in bituminous surface mines is 32 feet, although 100 feet of soil and rock are sometimes peeled away to get at a coal seam. The use of huge power shovels and draglines, scooping up as much as 50 cubic yards at a bite, enabled our bituminous surface mines in 1953 to produce 17 tons of coal per man-day, as compared with 6 tons in underground mines. Surface mines provide about one fourth of both our bituminous and anthracite coal.

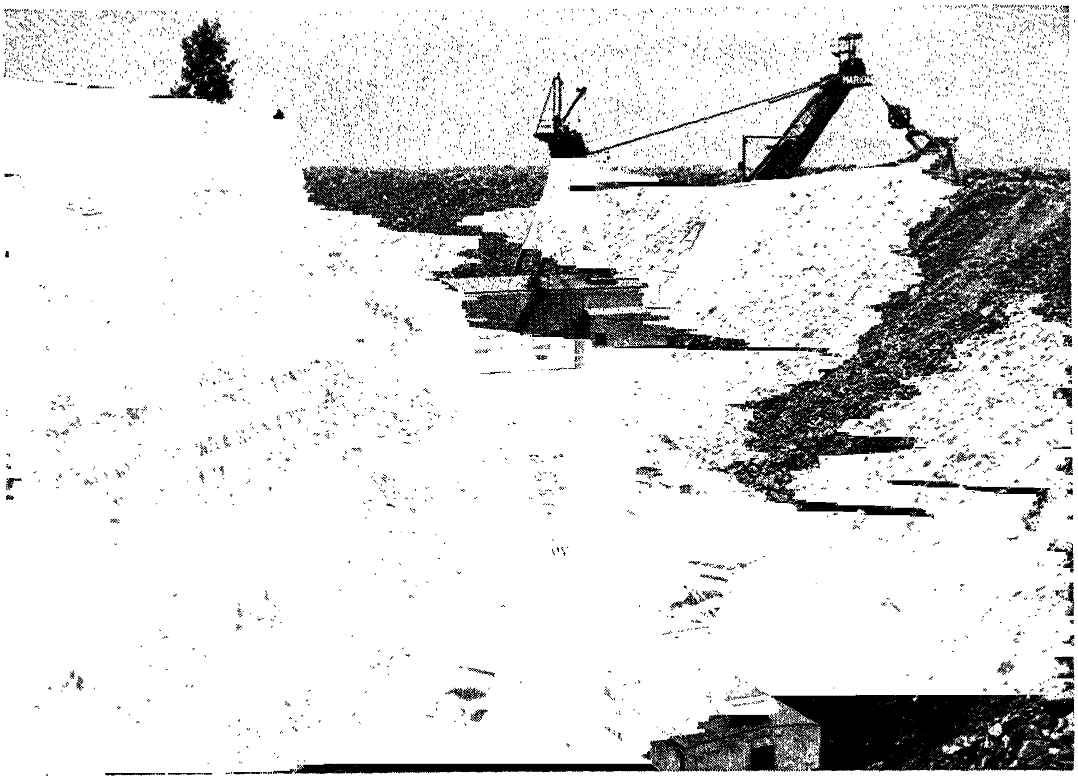
Underground mines. The task of obtaining coal by underground workings is more difficult and costly. Many problems must be solved besides the cutting and loading of coal, such as mine drainage, ventilation, safety, disposal of refuse, underground transportation, and hoisting. Geology, economics, and engineering are involved.

In drift mines the coal seam outcrops on the hillside and lies nearly flat, and the coal can be taken out as the tunnel is dug forward into the seam. In slope or slant mines, the coal outcrops on the hillside but lies in an inclined bed, so a sloping tunnel must be built to mine the coal. If the coal bed lies deep under the surface with no convenient outcrop, then a vertical shaft must be sunk to reach the coal seam. In the bituminous fields of the United States, drift mines account for 55% of the total output from underground operation, shaft mines account for 28%, and slope mines about 17%.

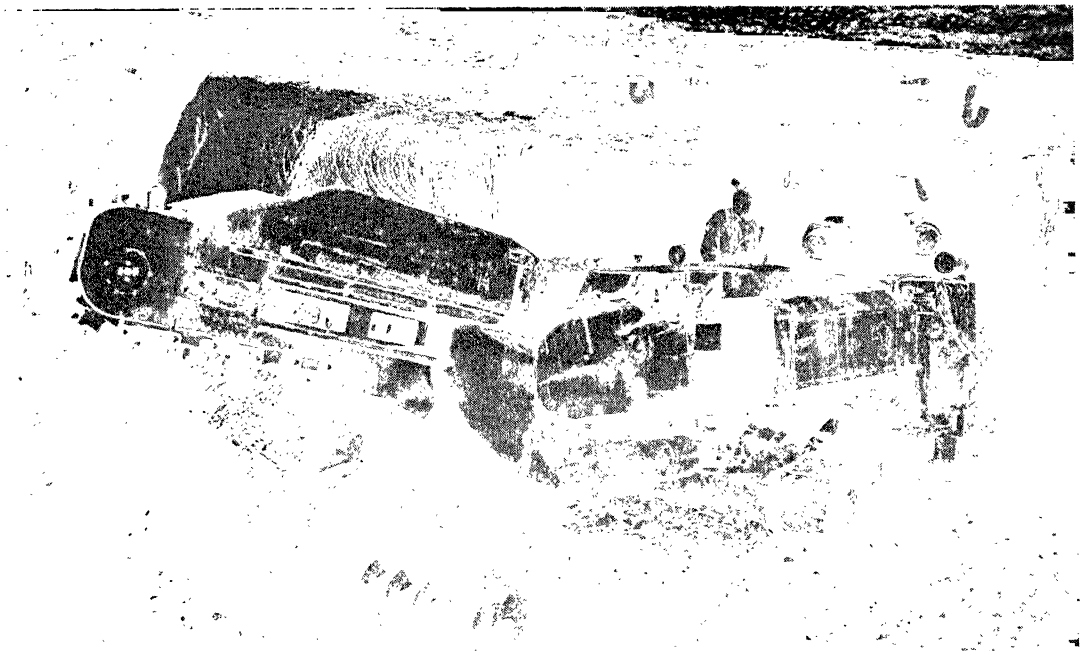
The usual method of working coal seams in U. S. underground mines is the room-and-pillar system. Rooms or chambers are cut out of the coal, the rooms being separated by walls or pillars of coal that are left to support the overlying strata of rock. About 1 ton of coal remains in the ground for every 2 tons of coal that are mined. In Europe the longwall system prevails. Nearly all the coal is removed from a continuously receding surface, and the excavated space is filled with rock and sand. Thus, Americans save labor but waste coal, while Europeans save coal but not labor.

Some American mines are so thoroughly mechanized that coal moves continuously from coal seam to mine mouth.[24] Let it not be forgotten, however, that all mining is subject to the law of diminishing returns—the greater the depth, the greater the cost per ton. While the average depth of bituminous mines in the United States is only 190 feet, in Europe the average depth is much greater, and in Belgium and Germany some of the shafts go down 4000 feet. Much of the world's coal will never be mined unless it becomes much more valuable. The last coal mining may be to get lubricants and chemicals, but who can foretell the distant future?

[24] See "Continuous Coal Mining," *Fortune,* June 1950, pp. 111–114 ff.



(Above) Strip mining. Savagery. Field becomes rock waste. Yield 4 feet coal. Big shovel lifts 35 cubic yards. Little shovel in foreground lifts coal. *Bituminous Coal Institute.* *(Below)* With claws and screws and revolving arms, this monster transfers 100 tons a day to a mine car or conveyor belt behind it. Man does not lift. *Joy Manufacturing Co.*



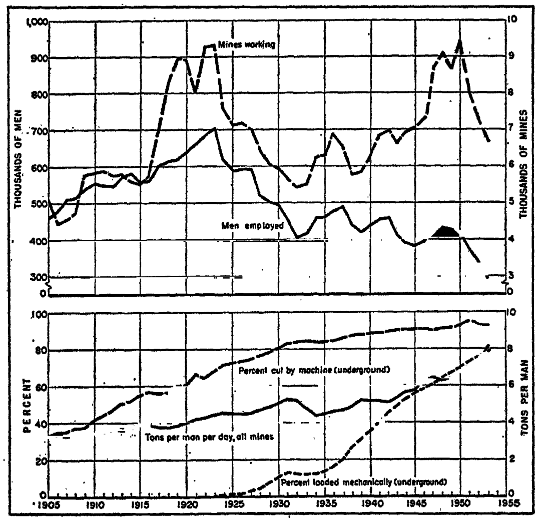
9. THE UTILIZATION OF COAL

Diversity of use. The amount of coal consumed and the manner in which it is used vary greatly among the nations of the world. Three fourths of the world's coal supply in prewar years was consumed by five great industrial nations—the United States, the United Kingdom, Germany, the Soviet Union, and France. In each of these countries approximately 60% of all coal was used by industrial plants, including those producing electricity and gas.[25]

Tiny, coal-poor Switzerland operates its railroads with hydroelectric power, while in Canada 41% of all coal is used for transportation. In the Cape Verde Islands 91% of the coal supply is sold as bunker fuel to ocean steamers, but in the Soviet Union only 1½% is so used. Norway has long cold winters, 77% of all coal being used for heating buildings, whereas tropic lands have no such need for heat. The use of coal depends not only upon the availability of coal and competing fuels but upon human abilities and human needs.

In 1953 the American people consumed 424 million tons of bituminous coal and 28 million tons of anthracite. Nearly all the anthracite was used for heating homes. Approximately one fourth of the bituminous coal was used by electric-power plants, one fourth by steel and coke producers, one fourth by other manufacturing establishments, only 9% by railroads, while most of the remainder was delivered to retail yards and later used for heating buildings. No other nation consumes so much coal.

Improvement in use. In the ordinary methods of using coal as fuel in fireplaces, stoves, and furnaces, much of the heat goes up the chimney in the form of gas and smoke. The coal-burning locomotive has long been a great waster of fuel, about half of its fuel being utilized for effective work. When beehive ovens are used in the manufacture of coke, the by-products are lost. Fortunately, the



Note how these graphs explain each other. See lower Fig. 302. *Minerals Yearbook, 1953*

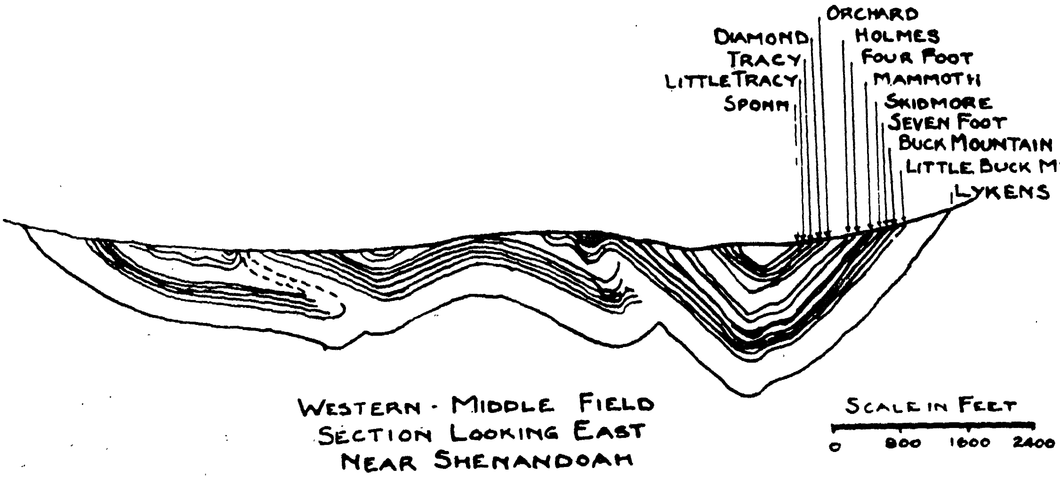
wizards of science are continually finding new and better ways for using coal.

A few years ago, the equipment of furnaces with automatic stokers and thermostatic control was a big improvement in the use of coal for heating homes. Smokeless heaters are now on the market that burn a variety of coals with remarkable efficiency and a minimum of care. In years to come, the heating of homes may be revolutionized by the electric heat pump, which extracts heat from the soil below the frost line and discharges it into the home, very much as the mechanical refrigerator takes heat out of food and discharges it into the kitchen.

The steam locomotive has been almost completely displaced by the efficient Diesel. Perhaps the Diesel will soon be challenged by a new locomotive of great efficiency, economy, power, and smoothness—the gas-turbine locomotive, burning pulverized coal.

In the United States coal dust and fine particles of coal are usually discarded as mine refuse, but the thrifty French, Germans, Belgians, and Dutch mix this material with an adhesive and compress it into briquettes that are widely used as household fuel. About one

[25] Dept. of State, *op. cit.*, pp. 17, 36–37.



The crooked, broken veins of anthracite. *U. S. Bureau of Mines*

half of the world's lignite is briquetted and used in households and electric-power plants.

Prior to World War II, the Germans and Russians made great progress in the underground gasification of coal and lignite. The gas is produced by the controlled burning of the seams and is piped away to industrial plants, thereby eliminating the cost of mining and reducing the cost of transporting fuel. The Germans, too, led the world in the distillation of gasoline and oils from coal and lignite. As yet these progressive methods have not been adopted commercially in the United States.

Coke and its by-products. Coke is used in the manufacture of iron and steel. It is made by heating coal in closed retorts, where the volatile matter is driven off as vapor and the coke is left in big lumps. These lumps are harder than the coal itself and therefore hold up the burden of the ore, so that the fire in the blast furnace does not smother. This vital service of coke is discussed in Chapter 20.

By the old coke methods, the coal was roasted in simple "beehives" or conical kilns of brick, and the gas and liquids were burned or allowed to escape as undesirable refuse. The modern by-product ovens for distilling coal are elaborate and expensive, but they quickly pay for themselves by converting this refuse matter into a great variety of useful and valuable products.

From 2000 pounds of bituminous coking coal are obtained 1300 to 1500 pounds of coke for use in the smelting of iron and other ores or for use as domestic or industrial fuel; 18 to 24 pounds of ammonium sulfate for the manufacture of fertilizers, explosives, and chemicals, and for use in refrigeration; 2½ to 3½ gallons of coal tar for the production of a thousand aniline dyes, pitch, flavoring extracts, perfumes, and many other things; and 9500 to 11,500 cubic feet of gas for heating and lighting.

In 1900 the by-product oven was in common use in Germany, while 95% of all coke in the United States was produced in wasteful beehive ovens. Today by-product ovens account for more than 90% of our coke production, and coal has come to be a basic raw material in an era of scientific research. More than 200,000 products are now derived from coal.

The future. The fact that we are mining such huge quantities of coal, a wasting asset, is causing some concern for fear of the exhaustion of our coal resources at a much earlier time than we previously thought possible. The price of coal is rising and must continue to rise. This turns our attention again toward substitutes, of which the chief are petroleum, natural gas, and water power in active competition with coal. Of these, the oil and gas may have an advantage of cheap-

ness while they last, but all the minerals are at best an accumulation soon robbed and are but ephemeral in comparison to water power which, depending upon the sun, the sea, and the highlands, remains an enduring source of power while climate and land endure.

When coal is used, it is gone forever. As the National Resources Committee warns us:

> In a sense the United States, and for that matter, the world, is "stranded" with a limited supply of mineral fuels. No one knows when a rescue party in the form of better sources of energy may arrive. In the light of experiences thus far with substitute sources, encouraging signs have been sighted. But the situation with regard to the total coal reserve is not precarious. If we are willing to make an increasing-cost sacrifice for coal mining, enough coal can be obtained to last for hundreds of years. What is important in the short run is the exhaustion of the best ranks of coal in the most readily minable beds near areas of large consumption.[26]

Obviously, we must conserve and use our resources wisely in order to live long. Will we ever think of ourselves as a *race* or a *civilization*?

Indian miners entering pit head, Bihar, India. Compare page 302. Developed? *Government of India*

[26] National Resources Committee, *Energy Resources and National Policy*, Washington, January 1939, p. 84. Charles W. Connor estimates that coal will last at least 1000 years at foreseeable consumption rates. "Coal—and Our National Economy," *Mineral Industries*, The Pennsylvania State College, Vol. 22, No. 3, December 1952.

18· Petroleum and Natural Gas—Fugitive Fuels

1. THE IMPORTANCE AND USE OF PETROLEUM

Ancient medicine, modern power. Petroleum is most commonly regarded as a source of fuel for the world's 83 million motor vehicles, but modern excavations on the sites of the old Babylonian and Assyrian Empires have disclosed bricks bound together with a petroleum asphalt base. The Greek historian Herodotus described a trade in petroleum about 400 years before the time of Christ.[1] It is known that the ancient Chinese made use of petroleum for medicinal purposes, as did medieval Europeans and the North American Indians. In modern times, however, petroleum's first great use was to provide light for the world.

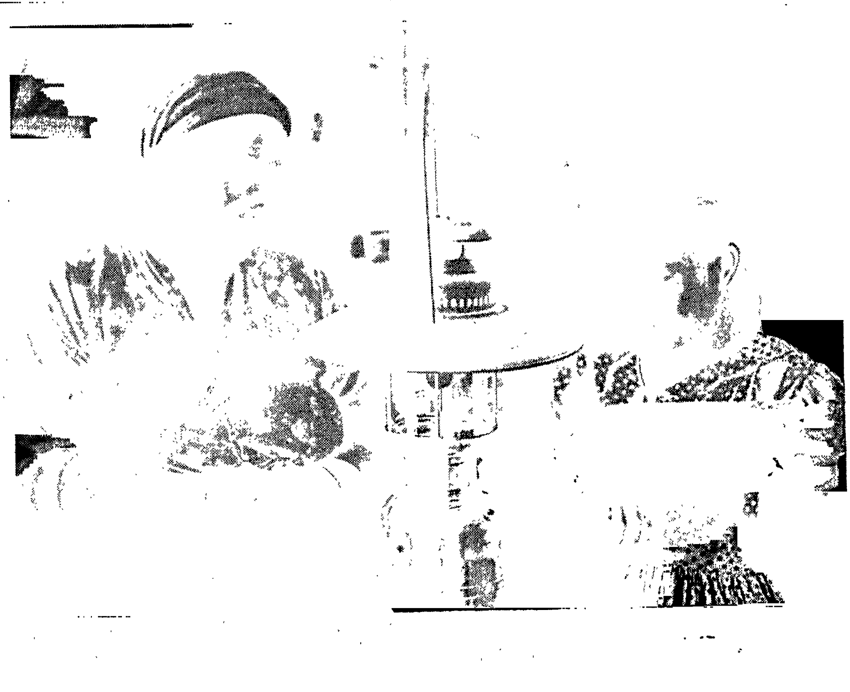
A source of light and lubricants. For ages mankind had groped at night in the gloom of the tallow candle or in the smoky light of some primitive oil-burning lamp utilizing various vegetable and animal oils. The lamps of southern Europe burned olive oil, whereas those of northern Europe and America used whale oil.

By the middle of the nineteenth century the demand for whale oil had become so great that the whales were threatened with extermination. Hence, distillation plants for producing illuminating oil from oil shale and cannel coal increased rapidly during the 1850's in both England and the United States. As the demand for coal oil increased in this country, the attention of American capitalists was directed to the strange black stuff called "rock oil" that oozed from the ground and spread a scum on the surface of creeks in western Pennsylvania. In 1857 the Pennsylvania Rock Oil Co. was organized. Edwin Laurentine Drake, a company employee and former railway conductor, was sent to investigate the company's landholdings along Oil Creek near Titusville, Pa., where he was introduced as "Colonel" Drake. Two years later he set up a crude derrick. After three months of drilling, Drake struck oil on August 27, 1859, at a depth of 69 feet. "Drake's Folly," as it had been dubbed by scoffers, yielded 2000 barrels of crude petroleum by the end of the year. Prospectors, diggers, swindlers, and other fortune hunters swarmed into the area and drilled furiously for oil, and America's first oil boom was under way. Little refineries were set up to obtain the prized kerosene, gasoline being burned or thrown away.

Kerosene—or "coal oil," as it was errone-

[1] George W. Stocking, "Oil Industry," *Encyclopaedia of the Social Sciences,* The Macmillan Co., New York, Vol. 11, 1933, pp. 438–439.

(Above) Kerosene—7 A. M. delivery sets out for 6 mile journey, Bombay. Why bullock? *(Right)* Kerosene—family lamp, Philippines, like scores of millions in remote places. *Standard Oil Co., N. J.*



ously called by most consumers—proved to be much cheaper than whale oil. The kerosene lamp invaded the homes of every continent, and for well over half a century it was the world's chief source of light. Indeed, kerosene still provides light for millions of homes throughout the world as well as serving as domestic fuel for cooking and heating. Today more than 5 million American homes are heated to some extent with portable stoves that burn kerosene.

Power, heat, and lubrication. Since 1913 the world has witnessed a tenfold increase in the energy supplied by petroleum, and it is probable that petroleum now performs one fourth of the world's daily output of work (see Tables 2:2 and 17:1). About three fifths of the world's petroleum is consumed in the United States, which has a per-capita consumption about 25 times that of the rest of the world.[2] In 1952 petroleum became our leading source of inanimate energy, now providing over 40% of our total supply.

In recent decades the greatest use of petroleum has been in the production of power from gasoline and fuel oil, which are the two principal derivatives of petroleum today. Tremendous quantities of gasoline are used every day to drive the world's automobiles and airplanes, and also many types of stationary engines. Vast amounts of fuel oil are used to operate ocean vessels and railway locomotives, to furnish power in factories, and to generate electricity. By providing lubricants and a compact and convenient fuel, petroleum has played a major role in revolutionizing transportation on land, on sea, and in the air.

While many products are derived from petroleum today, none renders a greater service to mankind than the oils and greases that are used to lubricate the countless moving parts of modern machinery. High-speed machines require careful lubrication to reduce friction to a minimum, and there is no good substitute for petroleum as a lubricant. Without petroleum, our proud Machine Age would grind quickly and ignominiously to a dead stop.

In the United States, where petroleum has long been so abundant and cheap, fuel oil is being used increasingly to heat buildings. The first domestic oil heater with thermostatic control was placed on the market in 1918. By 1950, 4½ million domestic oil heaters were in use, as compared with 3 million gas burners, and 1¼ million coal stokers. However, of the 21 million dwelling units equipped with central heating, nearly one half used coal as fuel.

Power, heat, light, and lubrication are the prime uses of petroleum today. Approximately 45% of all crude oil in this country leaves the refinery as gasoline, nearly 40% consists of fuel oil, and about 5% is kerosene. The remainder consists chiefly of lubricants, gas, asphalt, coke, road oil, and paraffin wax.

Petroleum by-products. Crude oil is a complex mixture of molecules of different kinds and many sizes and shapes. The petroleum chemist has learned how to separate the molecules, take them apart, and put them together in new combinations. By this method he improves oil products and creates new ones. More than 5000 different products have been developed from crude oil.

A major wartime achievement was the large-scale production of synthetic rubber. Two types, Buna-S and Buna-N, contain about 75% butadiene, a derivative of petroleum refinery gas. Buna-S made up 85% of United States rubber production during the war. Tires are made of Buna-S, which is now combined with natural rubber. Hydraulic hose, fuel hose, artificial leather, and various articles that are exposed to acids and oils are made from Buna-N. Inner tubes and conveyor belts are manufactured from Butyl, which is made entirely from petroleum derivatives, isobutylene and isoprene.

[2] Per-capita consumption in the United States increased from 7½ barrels in 1929 to 10 barrels in 1939 and to 17½ barrels in 1953. For an analysis of world patterns of civilian use of petroleum, see Wallace E. Pratt and Dorothy Good (editors), *World Geography of Petroleum,* American Geographical Society Special Publication No. 31, Princeton University Press, Princeton, 1950, pp. 354–393.

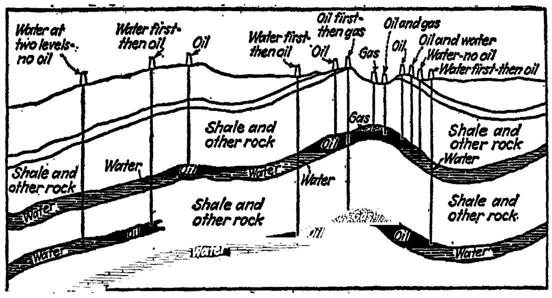
It is surprising how little is needed to produce so much. Only 1% of our crude oil is used for chemical synthesis, yet this provides nearly half of the organic chemicals manufactured in the United States. About 2% of all crude oil leaves the refinery as asphalt, which has been used to surface nearly 80% of our improved roads and 70% of our airports. Less than ½ of 1% of our crude oil could supply this country with all its rubber. Another fraction of 1% could supply us with alcohol.[3]

Each year American refineries use about $\frac{2}{10}$ of 1% of their crude oil to produce 4½ million tons of paraffin wax. More than three fourths of this wax is used in the packaging field for such articles as milk containers and wrappers for bread, butter, cereals, and frozen foods. Other uses include the manufacture of candles, candy, canning wax, chewing gum, detergents, floor wax, insulation, medical supplies, paper, and soap.

The meat-packing industry has long boasted that it uses all parts of a pig except the squeal. The petroleum industry sometimes adds the odor of oil to odorless gas to help detect leaks in pipelines. The petroleum industry claims that it uses everything in crude oil, including the smell.

2. THE ORIGIN AND NATURE OF PETROLEUM

Formation of petroleum. Theories differ regarding the exact origin of petroleum, but it is generally conceded that petroleum was formed from microscopic organisms that were originally intermingled with marine deposits and were subject to burial, pressure, and heat, which transformed them into a liquid or gaseous substance consisting chiefly of hydrogen and carbon. It is definitely known that petroleum is found in quantity only in sedimentary rocks, especially porous sandstones and limestones that hold petroleum much like a sponge holds water. In such rock formations, natural gas and water are generally found along with petroleum; and gas, being lighter than oil, is found above it.



Drilling for oil is often a gamble. Why? *American Petroleum Institute*

In some oil fields several oil-bearing strata are found one above another, separated by intervening rock formations of great thickness (see Fig. 309). In every case, the oil-bearing rock must be covered with clays, shales or other impervious rocks, or else the oil and gas will escape and leave asphalt on the earth at the point of escape. The oil and gas are seldom diffused uniformly throughout the porous rock but usually gather in a pocket or pool at the top of an anticline or dome capped by impervious rock, the pressure of ground water beneath forcing the oil and gas upward into the pocket. Hence, the world's great petroleum deposits are found in plains or plateau areas where the nearly horizontal rock strata have not been disturbed by excessive folding or faulting of the earth's crust, which would have ruined the natural oil pockets by cracking their impervious covers.

A fugitive resource. Because of its hidden and uncertain location beneath the surface of the earth, because of its peculiar structural formation, and because of its liquid and gaseous nature, petroleum is one of the most elusive of all the resources that are used by man. From the very beginning, the petroleum industry has been confronted with uncertainty.

In the first place, there is the perplexing uncertainty about the size of petroleum reserves, and for years the industry has been torn between the dire warnings of the pessimists, who

[3] See American Petroleum Institute, *Facts about Oil*, New York, 1950, pp. 21–22, and Stewart Schackne and N. D'Arcy Drake, *Oil for the World*, Harper and Brothers, New York, 1950, p. 78.

claim that the petroleum supply will not last longer than a decade or two, and the rosy predictions of the optimists, who assert that the supply will last for a century or two. The fact is that the best geological estimates are merely educated guesses, that every estimate to date has been subsequently proved wrong, and that we simply do not know how much petroleum remains in the ground in the United States or any other country.

Secondly, there is the uncertainty in locating petroleum deposits. For a long time prospecting was entirely a matter of random drilling, or hit-or-miss methods known as "wildcatting." Today skilled geological and geophysical crews use such modern equipment as the seismograph, the torsion balance, the magnetometer, the electric log, and the aerial camera to determine the possible location of oil,[4] yet, in spite of all the advancements of science, there is no sure formula for discovering oil.

Thirdly, there is the uncertainty involved in competitive drilling, together with a tremendous amount of waste. It is perfectly legal for your neighbor to drill a well and to drain out the oil from under your land, and your only recourse is to drill as promptly as he does. Hence, as soon as oil is discovered in a given locality, everyone drills for oil, and the terrain is soon transformed into a veritable forest of derricks and (perhaps) gurgitating gushers. Far more wells are put down than are necessary, and the gas on top of the oil often escapes, and its pressure is lost. This might well have been used to help force petroleum out of the ground. Because of this folly, much petroleum remains underground that cannot be recovered except by expensive pumping. In the mad scramble for oil, the landowner is certain only of the oil that he can actually get from under his land.

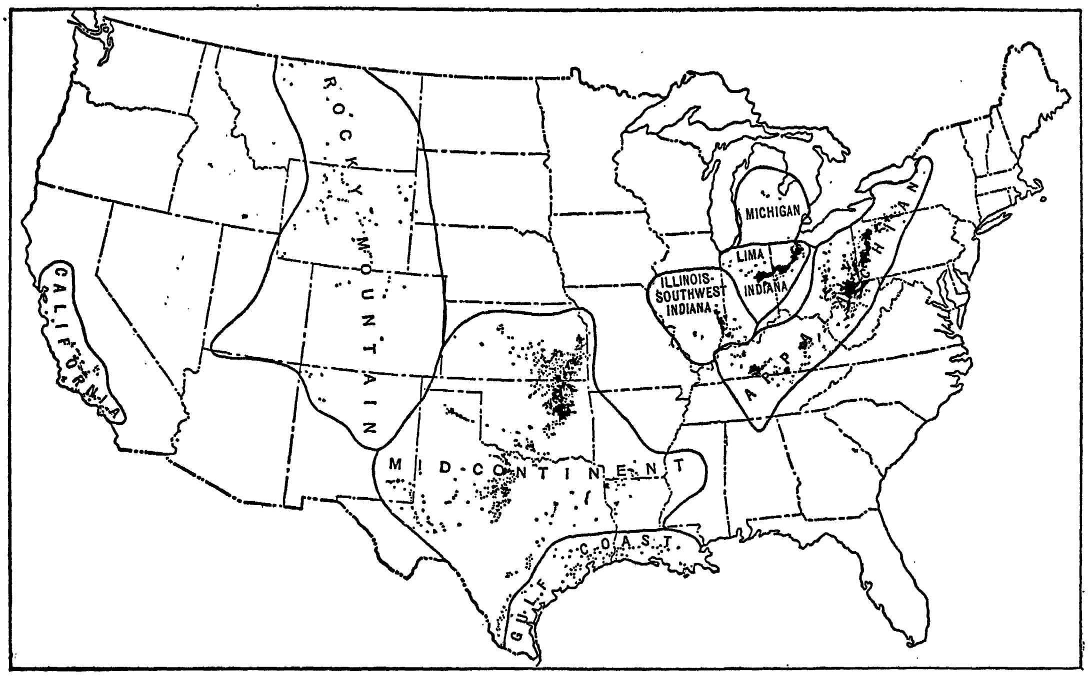
Fourthly, there is the uncertainty of the volume and length of the yield. An oil well may gush forth its wealth for decades, or the dreaded salt water may appear after a few years or months, indicating an end of the oil supply. Hence, production has been characterized by alternating feasts and famines, together with great changes in the price of petroleum.

Finally, there is the uncertainty of financial return to the investors, all of whom seem to think that they will strike it rich. The gamble of drilling for oil has such a powerful speculative appeal to the investing public that there seems to be no end to the amount of capital available for drilling, which in itself is a powerful force contributing to instability.

Petroleum is indeed a highly elusive resource, the development of which has long been characterized by uncertainty, haste, waste, vicious competition, and sometimes overproduction. The one sure thing about petroleum is the fact that petroleum resources are exhaustible.

Thus far the petroleum industry has been able to ward off the evil day of exhaustion through continuous prospecting, through the use of more scientific prospecting methods, through good luck in finding more petroleum deposits, through better drilling methods that can now bore 21,000 feet into the earth, through better methods of extracting the oil, and through improved refining techniques that utilize petroleum more efficiently. Fundamentally, however, the quest for oil is a race between discovery and disaster. How long man will continue to discover new oil fields is a moot and vital question.

[4] The petroleum surveyor sets off nitroglycerine charges at various points, and the different sound waves recorded on his seismograph reveal whether or not there are dense subterranean areas or domes in the underrock where oil might be found. The torsion balance, which can record a change in rock density as small as one part in a million million, shows differences in gravitational pulls in various parts of a region and helps the surveyor to determine underground formations. The magnetometer records the magnetic pulls of different kinds of rocks and easily reveals the presence of sedimentary rocks, which are poor transmitters of the earth's magnetism. The electric log shows the permeability of subterranean beds. The aerial camera exposes surface formations that might not be seen by the petroleum surveyor who travels on foot. The airborne magnetometer, or "flying doodlebug," can map large areas of land or sea in a few hours.



This and Fig. 271 top show that East beats West in good fuel. Midcontinent field produces more than half our oil. *National Resources Committee*

3. THE OIL FIELDS OF THE UNITED STATES

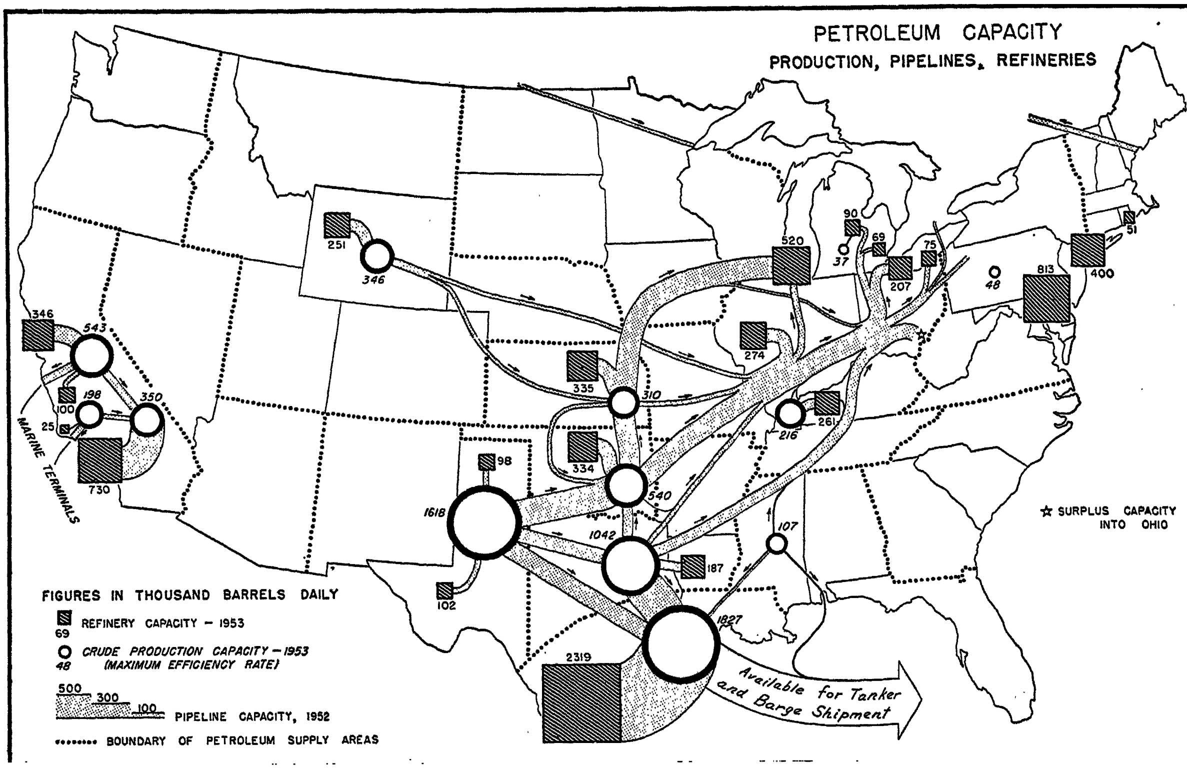
Growth of production. The prominence of the United States in oil production has been largely due to the great wealth of our petroleum deposits, to the fact that petroleum was first developed on a large scale here, and to our leadership in automotive transportation with its increasingly voracious demand for gasoline. The phenomenal increase in American petroleum production has occurred since 1908, when the unprecedented output of 10,000 Ford cars in a single year ushered in the large-scale manufacture of automobiles. Our average annual production of petroleum increased from 217 million barrels in 1909–13 to 1171 millions in 1935–39, and to 1885 millions in 1946–50.

In World War II the Allies floated to victory on a flood of oil, and the United States produced six sevenths of the total Allied supply. Our wartime production reached a peak of 1714 million barrels in 1945, but this peak has been surpassed in every postwar year. The production of 2360 million barrels in 1953 marked an all-time record for the American petroleum industry. Since 1859 more than 48 billion barrels of petroleum have been taken from the ground. More than half this staggering total has been produced since 1938. We now produce one half of the world's oil.

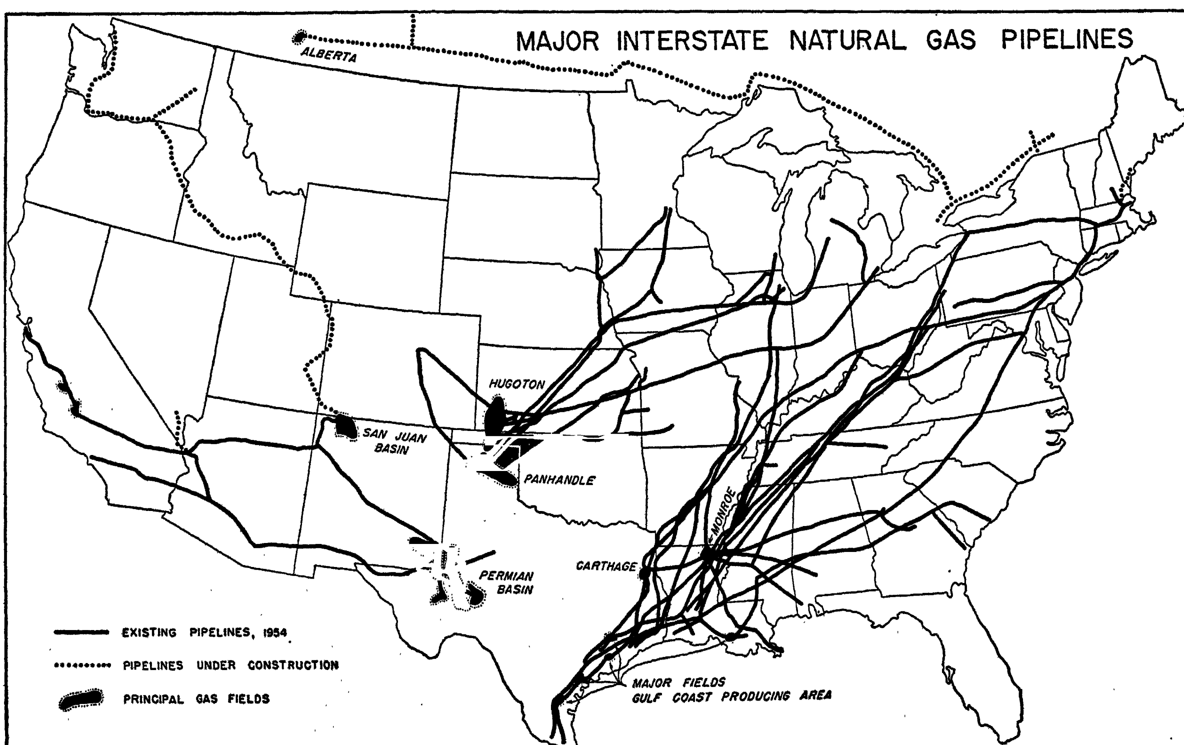
The pioneer Appalachian field. As the accompanying map reveals (see Fig. 311), there are eight distinct petroleum-producing regions or major oil fields in the United States. The oldest, known as the Appalachian, runs from southwestern New York through western Pennsylvania, eastern Ohio, West Virginia, Kentucky, and Tennessee.

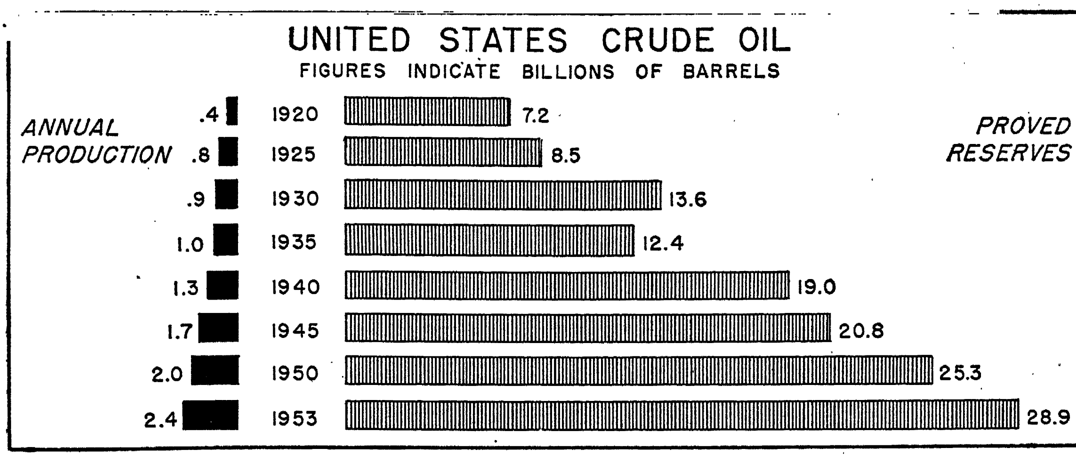
Not long after the discovery of oil, towns bearing such suggestive names as Oil City, Olean, and Petrolia grew rich from small beginnings, and Pittsburgh, Cleveland, Erie, and New York City were among the first great refining centers.

Pennsylvania now produces only one third of the maximum output of 33 million barrels which it achieved in 1891, and the average yield of an oil well is only one third of a barrel per day. ~~The entire Appalachian field accounts~~



(Above) Major interstate petroleum pipelines. Illustrates many points in text. Note flow, arrows, to Gulf and Great Lake shores. Why no pipes in the Atlantic states? *Adapted from Petroleum Administration Defense, Transportation of Oil, 1951. (Below)* Gas must go in pipes; moves easier than oil. *James Parsons, University of California, and Federal Power Commission*





Much history here. Reserves increase; production faster. See Fig. 314 bottom. ***American Petroleum Institute***

for less than 1% of the nation's output. However, the high quality of the oil and nearness to market enables Appalachian oil to command the highest price in the United States.

The Lima-Indiana, Michigan, and Illinois fields. The second discovery of importance in the United States was the Lima-Indiana field, which crosses the northern part of the Ohio-Indiana boundary, with its center in Lima, Ohio. Commercial production got under way in 1876, Ohio reaching its peak 2 decades later. As the data in Table 18:1 reveal, this field is practically exhausted. Its present annual output of less than 130,000 barrels is obtained by the use of pumps.

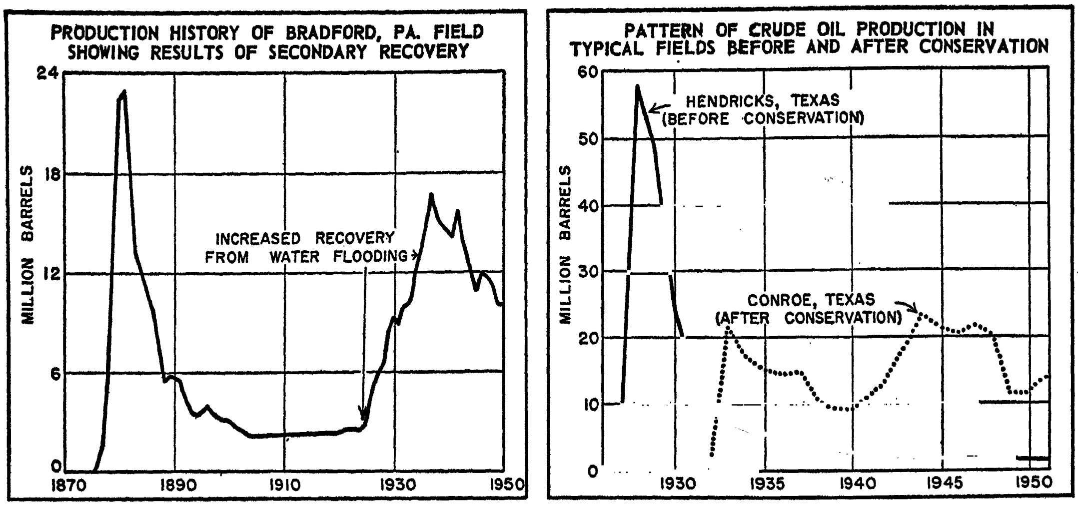
The Michigan field was opened in the early 1920's. Production in 1953 amounted to 12 million barrels, as compared with a peak of 23 millions in 1939. Oil was discovered in Illinois in 1889, reached a peak of 33 million barrels in 1910, and then declined. Important new discoveries and deeper drilling in the late 1930's rejuvenated the Illinois-southwestern Indiana field, the Salem, Louden, and Centralia districts being the leading producing centers. While production averaged only about 5 million barrels in 1931–35, it increased rapidly to an all-time peak of 148 million barrels in 1940 and then declined.

The great Midcontinent field. The world's greatest petroleum region is our vast Midcontinent field, which has yielded over half our output to date. Commercial production began in 1889 near the town of Neodesha,

TABLE 18:1. Production of Crude Petroleum in the United States, by Regions, 1901–53
(millions of barrels)

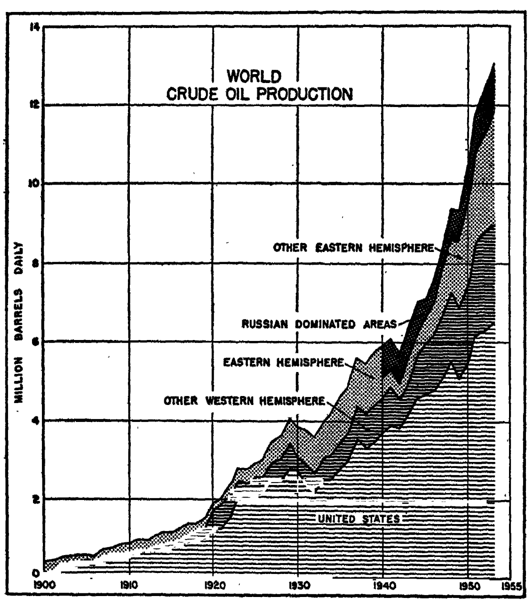
Region	1901-10 av.	1911-15 av.	1916-20 av.	1921-25 av.	1926-30 av.	1931-35 av.	1936-40 av.	1941-45 av.	1951-53 av.
Appalachian	28.9	24.6	27.2	28.5	31.6	30.1	34.8	34.0	33.6
Lima-Indiana[a]	17.3	5.1	3.5	2.3	1.7	1.1	0.6	0.3	0.1
Michigan	....	....	....	0.001	1.9	9.0	18.1	18.9	13.2
Illinois-S.W. Indiana[a]	12.7	25.0	13.9	9.6	7.5	5.3	57.6	100.6	71.7
Midcontinent	25.1	87.7	184.6	343.6	527.9	566.3	694.8	764.3	1270.7
Gulf Coast	17.4	12.4	24.3	33.7	54.1	75.4	178.3	294.0	433.8
Rocky Mountain	0.4	2.6	11.8	35.3	29.5	18.0	27.8	44.8	116.4
California	35.6	90.5	97.4	195.1	241.5	184.2	230.3	280.2	359.6

[a] Southwestern Indiana was reported with the Lima-Indiana region prior to 1921.
Source: U. S. Bureau of Mines.



Flooding brings out oil that will not flow. One reason for increase in reserves. *National Petroleum Council, Washington, D. C.*

Kans., but important production in this field was not achieved until 1896, when the Corsicana pool was opened in Texas. Production



How many times doubled: Other West, chiefly Caribbean; Other East, chiefly Middle East. U. S. share declines. Largest exporters are Caribbean and Middle East. *Data from Oil and Gas Journal*

in Oklahoma was begun in 1902 and increased rapidly after the discovery of the Bartlesville pool in 1904 and the Glenn pool in 1906. Northern Louisiana started to produce oil in 1898, southern Arkansas in 1921, and southeastern New Mexico in 1923. Oklahoma City began its boom cycle in 1929, and the Kilgore boom in the following year unleashed a deluge of oil in east Texas. Today west Texas is having its boom. Thus, one new oil pool after another has come roaring in, each achieving temporary wealth and fame. At the present time the great Midcontinent field is producing more oil than all other fields in this country combined, and its output is more than double that of Venezuela, the leading producer abroad. Indeed, Texas alone produced over 1 billion barrels of crude oil in 1953, or 44% of our nation's output. The Midcontinent field has by far the largest proved reserves in the United States,[5] and production has not even approached its zenith.

The Gulf Coast field. This field in Texas and Louisiana was opened with the discovery of the famous Spindletop pool near Beaumont, Texas, in 1901, where the scramble for oil led to the drilling of 6 wells per acre, in-

[5] Proved crude oil reserves on January 1, 1954, in billions of barrels: United States total 28.9; Texas 15.0, California 3.9, Louisiana 2.8, Oklahoma 1.7, Wyoming 1.3, Kansas 0.9, New Mexico 0.8, Illinois 0.6, Mississippi 0.3, all others 2.6. The Independent Petroleum Association of America, *The Oil Producing Industry in Your State,* Tulsa, Okla., 1954.

volving profligate duplication and waste. The oils of this field contain a low percentage of gasoline and a high percentage of sulfur and residue; hence, they are less valuable for refining than those of the Midcontinent and Appalachian fields but are particularly useful in the production of fuel oil. Since 1943 the Gulf Coast has ranked second to the Midcontinent field in production. Year after year large shipments of crude and refined products move by ocean tanker from Gulf ports to the large markets along our northeastern seaboard.

The Rocky Mountain field. The development of petroleum in the Rocky Mountain field lies chiefly in the future, for this region is least accessible to the nation's leading markets. Many producing districts are scattered throughout this large region, which extends from central New Mexico to the Canadian border. Wyoming has the largest proved reserves in this region. In 1953, with an output of 85 million barrels, Wyoming ranked sixth among our oil-producing states. As a consequence of new exploration and deeper drilling, production in the Rocky Mountain region has trebled since 1939. Fortunately, thousands of acres of oil land are owned by the United States government which may render great service in the future.

California. This state has felt the exhilaration of many booms, including the famous Gold Rush, a wheat boom, a citrus boom, a movie boom, an almost continuous real estate boom, and also two of the country's greatest oil booms. While oil was produced in California as early as 1886, large-scale production did not get under way until the following decade, when important discoveries were made in the Los Angeles and Bakersfield areas. From that time on production increased rapidly, and California came to lead all states in 1909–14 and again in 1923–26. Maximum production was reached in 1953 amounting to 365 million barrels, most of which was produced in Los Angeles and adjacent Kern and Orange counties. Of late California has obtained oil from Texas.

In view of the phenomenal developments in the U. S. petroleum industry during the present century, it is difficult to realize that in 1900 the Appalachian and Lima-Indiana fields led the nation with outputs of only 36 and 22 million barrels respectively. Fame and fortune achieved through the exploitation of this fugitive resource are indeed ephemeral, since decline and exhaustion are the inevitable fate of every oil field, no matter how big, boisterous, and prosperous it may be at the present time.

4. FOREIGN OIL FIELDS

Canadian fields. Canada's first oil well was drilled in southwestern Ontario in 1859, and it may have preceded Drake's famous well at Titusville, Pa.[6] However, no gushers were struck in Ontario, and the yield per well was generally small. No large oil fields were discovered in eastern Canada. For years Canada has had to import about 90% of its oil supply.

It was not until 1914 that oil men made their first strike in the Canadian West, when oil was found in the Turner Valley in southern Alberta. Later discoveries were made in 1920 at Norman Wells in the Mackenzie Valley near the Arctic Circle, and in 1939 at Lloydminster near the Saskatchewan-Alberta boundary. The results, however, were generally meager. During World War II petroleum products had to be shipped into Alberta and Saskatchewan by tank car from points as far as Texas, some 2000 miles away.

In February 1947 Alberta struck it rich with the discovery of a big oil field at Leduc near Edmonton. This was followed by the discovery of the Redwater field and other large oil pools. To make Albertan oil accessible to the markets of eastern Canada and the U. S. Midwest, a 1180-mile pipeline was completed in 1950 from Edmonton to Superior, Wis., at the head of navigation on the Great Lakes, and then on across U. S. land to Sarnia,

[6] Nels. A. Bengston, "Petroleum in Relation to Current Problems—II. Canada's Increasing Prominence in the Petroleum Industry," *Journal of Geography*, March 1951, p. 103.

Ontario, near Detroit. In 1953 another pipeline was completed over the Rockies to Vancouver, British Columbia.

In Alberta nearly all oil rights are owned by the provincial government, and private companies are developing the oil fields under lease. From royalties and lease sales the government gets about half of all income from oil. The government permits only 1 well on each 40 acres and sets a flow quota for each producing well. Hence, there is little chance for a fly-by-night operator to sink a well nearby and siphon off his neighbor's oil.

Between 1947 and 1953 Canadian crude-oil production increased from 8 to 81 million barrels, and 95% is now produced in Alberta. The time is not distant when Canada will be independent of foreign oil.

In the Lake Athabaska region of northern Alberta and Saskatchewan are several hundred square miles of fabulous tar sands; estimated content, 200 billion barrels of oil. This deposit of petroleum residue is the largest known accumulation of petroleum in the world. Unfortunately, the tar sands lie locked in an asphaltlike sandwich, and as yet they are too intractable for commercial use.

Caribbean fields. Venezuela is the world's greatest exporter of petroleum and ranks second only to the United States in production. Approximately one third of Venezuelan exports are destined for consumption in the United States, one third is destined for Europe, and most of the remainder for South American countries, Canada, and Central America. Only 1½% of the total output is used in Venezuela.

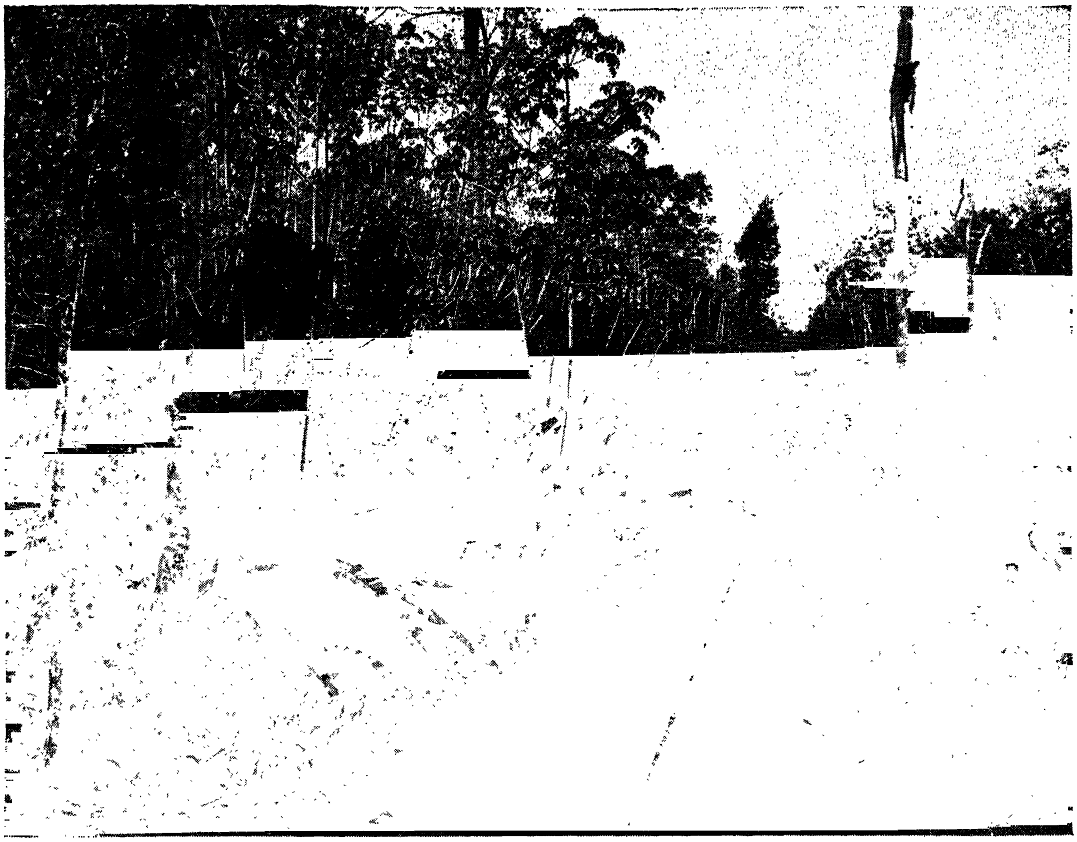
Between 1939 and 1953 Venezuelan production increased from 213 to 644 million barrels. About two thirds of the oil is produced around Lake Maracaibo where some derricks are 18 miles out in the lake. Because of a sandbar across the northern neck of the lake, it has long been necessary to ship the crude oil in shallow-draft tankers to the nearby islands of Aruba and Curaçao for transshipment to foreign markets, much of the oil being refined on the islands prior to transshipment. Since 1949 a part of Maracaibo's oil has moved northeastward through a new pipeline to a deep-water terminal at Amuay on the Paraguaná peninsula.

New oil fields are being developed in the Orinoco-Apure Basin, which now accounts for about one third of the nation's output. Most of the oil moves through pipelines to Puerto La Cruz on the Caribbean coast and to Caripito on the navigable San Juan River that empties into the Gulf of Paria near the mouth of the Orinoco. Among Venezuela's largest refineries are those at Puerto La Cruz, at Caripito, and on the Paraguaná Peninsula. About one fifth of all oil is refined in Venezuela prior to exportation.

Over $2 billions of American and British capital have been invested in the Venezuelan oil industry. The nation's share of 50% of the oil companies' net profits now provides 60% of the government's revenue, the highest public revenue per capita in South America. The nation has no external debt, a negligible internal debt, a stable monetary unit, and no personal income taxes. This seems like the answer to an economist's prayer.

Mexico, the second largest oil producer in Latin America, has had its ups and downs. In 1921 Tampico was the world's leading oil port. From an all-time peak of 193 million barrels in 1923 production declined to 33 millions in 1932, fluctuated between 35 and 62 millions during the 1940's, and amounted to 73 millions in 1953. The oil fields have been owned and operated by the Mexican government since 1938, when it expropriated British and American property worth $450 million. Less than one fourth of Mexican oil is now exported.

In Colombia two thirds of all oil production occurs around Barrancabermeja, a refining center along the lower Magdalena River. Most of the oil is shipped by pipeline to the Caribbean port of Mamonal for export, the remainder being refined for domestic use. About one third of the nation's oil is produced in the Colombian portion of the Maracaibo basin, which is linked by pipe-



On such a tropic jungle pipeline in eastern Colombia 20 operatives were speared from ambush in a few months by natives who hated whites. ***Standard Oil Company of New Jersey***

line with the Caribbean port of Coveñas. Total production amounts to nearly 40 million barrels a year, and oil now ranks second to coffee among Colombian exports.

On the island of Trinidad oil is produced by private corporations on land owned by the British government. Because of governmental control, no more wells are drilled than are necessary to obtain the oil. You can ride through the oil field and wonder when you are going to reach it. Since 1939 production has varied between 19 and 22 million barrels a year.

Remainder of South America. In South America more than 80% of the land and population are found south of the Equator, whereas more than 90% of the crude oil is produced north of it, namely, in Venezuela, Colombia and Trinidad.[7] Each of these Caribbean countries exports a large fraction of the product. Crude oil is also produced at Talará in northern Peru, around Santa Cruz in eastern Bolivia, and on the Santa Elena peninsula of Ecuador. Each of these countries has a small surplus for export.

The industrial leaders of South America must import petroleum products. Argentina's annual production of about 25 million barrels, chiefly in the Comodoro Rivadavia field, meets two thirds of her needs. Brazil and Chile each produce less than 1 million barrels of crude oil a year, and they import more than 95% of their petroleum supplies. Argentina, Brazil, and Chile hope to discover more oil.

Russian and Rumanian fields. With the exception of its southeastern corner, the continent of Europe is poorly endowed with petroleum. The annual production of the whole of

[7] Pratt and Good, *op. cit.*, p. 364.

Europe, excepting the Soviet Union and Rumania, is less than 40 million barrels. West Germany and the Netherlands are the leading producers in the west.

Although Russian crude-oil production led the world in 1898–1901, it usually ranked second to U. S. production from 1873 to 1945, when Venezuela achieved second place. It increased rapidly from 63 million barrels in 1913 to 217 millions in 1939, and to an estimated 365 millions in 1953.

The greatest of Russian oil fields is the old Baku field on and near the Apsheron Peninsula along the west coast of the Caspian Sea. In 1950 this field accounted for 42% of the nation's output, as compared with 70% in 1940.[8] Another field, which has come to be known as the "Second Baku," lies north of the Caspian Sea between the Volga River and the Ural Mountains. It serves the newly developed Ural-Volga industrial district and accounts for about one third of the nation's output. Other producing areas are the Emba Basin northeast of the Caspian Sea, the Grozny and Maikop fields on the slopes of the Caucasus Mountains, and minor fields in the Urals, Turkestan, and the island of Sakhalin.

Prior to World War I, large quantities of crude oil were shipped by tanker to the markets of northwestern Europe, but under the Soviet regime virtually all has been used at home. Pipelines lead from the Emba field to Orsk in the southern Urals, from Baku to Batum on the Black Sea, and from the Grozny and Maikop fields to the Black Sea port of Tuapse and to Dnepropetrovsk on the Dnieper River. The Caspian and Black seas, the rivers, and the canals are very useful in moving petroleum to domestic markets.

In 1857–59 Rumania led the world in crude-oil production, with an annual output of less than 4400 barrels, and then was eclipsed by the United States. The Rumanian oil fields are concentrated in a small area, only 9 by 30 miles in extent, around Ploesti, the refining center. Rumanian production reached its peak of 64 million barrels in 1936, declining to 46 millions in 1939 and to about 33 millions in 1953. Prior to World War II large quantities of Rumanian oil moved by barge up the Danube into central Europe and by ocean tanker to northwestern Europe. Most of it now goes to the Soviet Union, a new pipeline linking Ploesti with Odessa.

The Middle East. Geological research has revealed that about 58% of the world's proved petroleum reserves are concentrated in lands bordering the Persian Gulf, namely, Saudi Arabia, Qatar, Bahrein Island, Kuwait, Iraq, and Iran (see Table 18:2).[9] The remainder of the world's reserves are divided as follows: United States, 21½%; Caribbean countries, 10%; the Soviet Union, 6½%; and the rest of the world, only 4%.

TABLE 18:2. Crude Oil Reserves and Production in 1953
(millions of barrels)

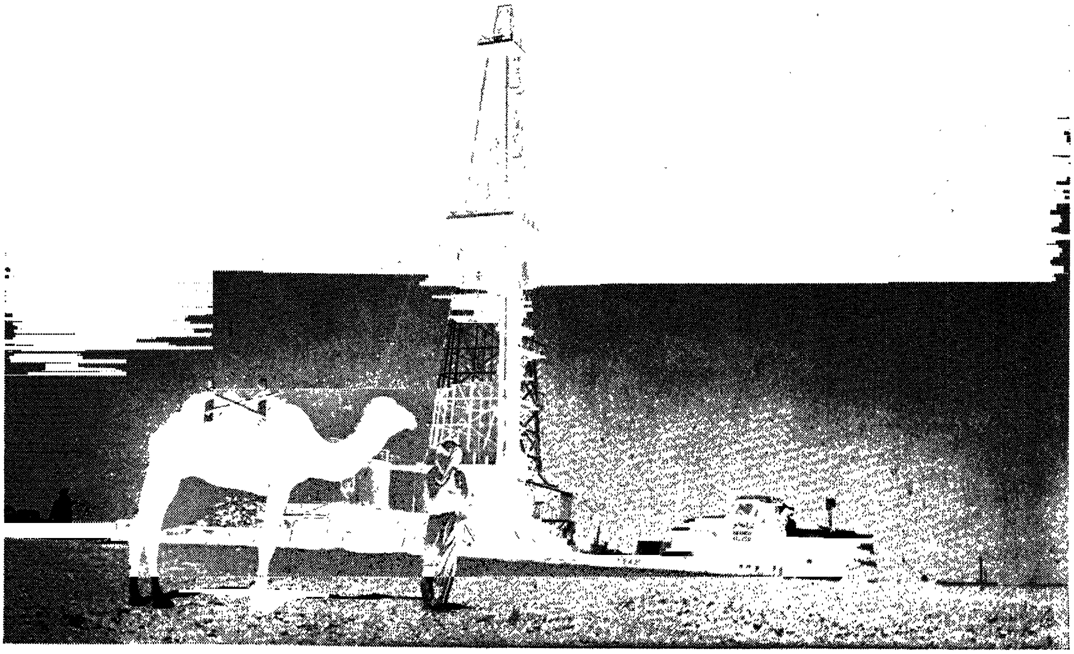
Country	Reserves	Production
United States	29,044	2360
Saudi Arabia	28,000	309
Kuwait	20,000	315
Iran	15,000	9
Iraq	13,000	211
Venezuela	9,900	644
U. S. S. R.	9,000	365
Indonesia	2,450	77
Canada	1,950	81
Mexico	1,725	73
Qatar	1,500	31
Colombia	550	39
All others	3,140	233
World total	135,259	4747

Source: Reserve data as of January 1, 1953, *Oil and Gas Journal*, December 21, 1953, pp. 118–119. Production data, American Petroleum Institute.

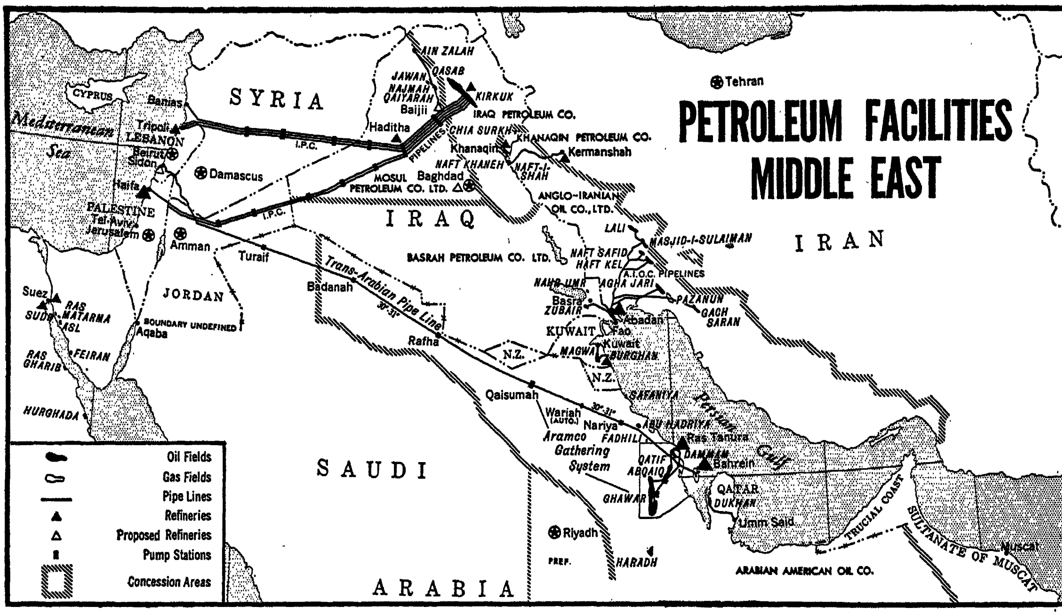
The successful production of crude oil in the Middle East began in 1908 in the Masjid-i-Sulaiman field of Iran (then Persia). Production increased from 2 million barrels in 1913 to 66 millions in 1939, and to 242 mil-

[8] J. H. Carmical, "Russian Oil Lack, Critical Handicap," *The New York Times*, Section 3, July 1, 1951, pp. 1–2.

[9] See Pratt and Good, *op. cit.*, pp. 159–299, and Dahl M. Duff, "Over Half of World's Reserves Now Concentrated in Middle East," *Oil and Gas Journal*, December 21, 1953, pp. 117–119 ff.



(Above) Such rigs, minus tanks, are moved intact across level sand by teams of tractors. *Arabian American Oil Co.* *(Right)* American know-how being received at second hand. Many peoples can learn quickly. *Standard Oil Company of New Jersey*



Area 1500 miles long. Arabs' chance to play with political fire. Note pumping stations. Poor market for gas as gas. *World Petroleum, March 1953*

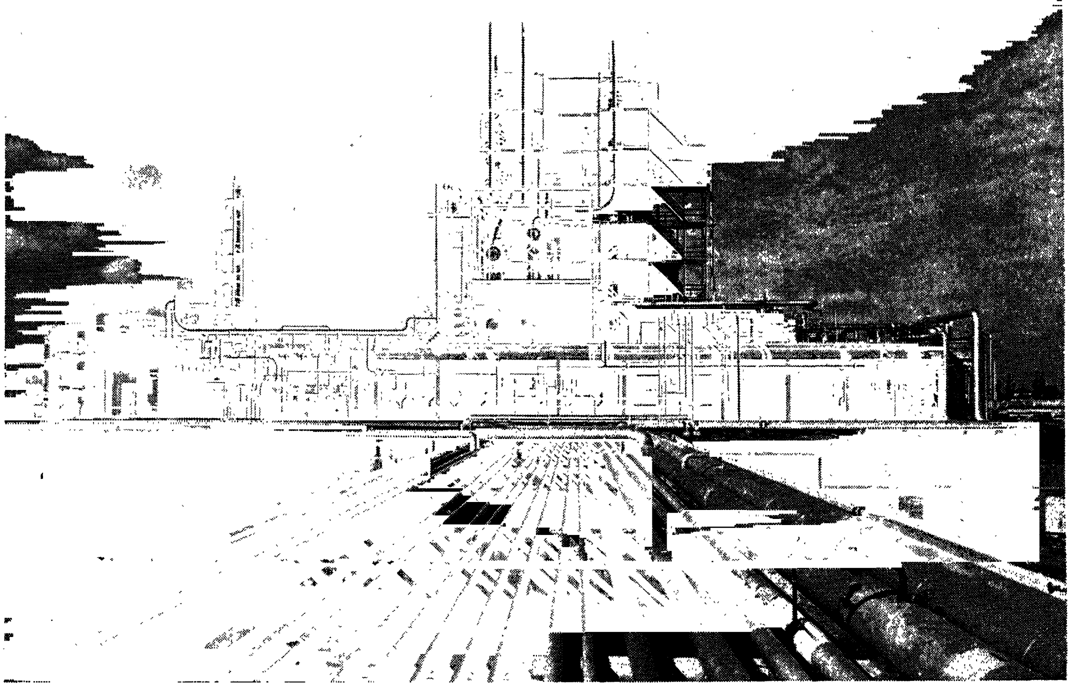
lions in 1950. Pipelines link the chief fields with the nearby port of Abadan, site of the world's largest refinery, which has a capacity of 540,000 barrels a day. Prior to 1951 the oil fields were exploited by the Anglo-Iranian Oil Co., in which the British government is the majority stockholder. Disputes between the Iranian government and the company led to nationalization of the industry in 1951 and complete stoppage of production. In 1953 Iranian fields produced only 9 million barrels of oil. Oil production obviously requires a climate of political and financial security. Today the oil fields and refinery are being operated with the aid of American, British, French, and Dutch capital and personnel. The Iranian government receives a good royalty for the use of the property.

In Iraq the discovery of oil at Baba Gurgur in 1927 marked the opening of the huge Kirkuk field. Large-scale production did not get under way until 1934, when pipelines were completed across the desert to the Mediterranean ports of Tripoli in Lebanon (then part of Syria) and to Haifa in Israel (Palestine). In 1952 another pipeline was completed to Banias, Syria. Production increased from 1 million barrels in 1933 to 31 millions in 1939, and to 211 millions in 1953.

Bahrein Island produces about 11 million barrels of crude oil a year, and its refinery processes local oil and some Saudi Arabian oil that reaches the island by a 25-mile submarine pipeline. The nearby sheikdom of Qatar has an output about treble that of Bahrein.

Saudi Arabia, with an annual output of about 308 million barrels, is a major producer in the Middle East and a close rival of the United States in reserves. The first oil strike was made in 1936 in the Dhahran field near Ras Tanura. This was followed by other discoveries, including the great Abqaiq and Ghawar fields. In 1944 a refinery and wharf facilities were constructed at the port of Ras Tanura. In 1950 a 1068-mile pipeline was completed across the vast desert, linking Ras Tanura with the port of Sidon in Lebanon. This pipeline, costing $200 million, has a capacity of 350,000 barrels a day and greatly reduces the need of long tanker voyages around the Arabian peninsula through Suez.

Little Kuwait, smaller than Delaware, ranks third only to the United States in oil reserves and fourth among the oil-producing nations of



Socony Vacuum Oil Co. refinery, England. Queen Mother dedicated it in 1954. Royalty, cabinet members, and U. S. oil company officials dedicate such international investments. ***Socony Vacuum Oil Co.***

the world. The great Burghan field is operated by a British-American company, and the royalties received by the ruling sheikh make him one of the world's richest men.[10] From a geopolitical viewpoint, the oil wealth of the entire Middle East lies temptingly close to the Soviet Union and right beside the master east-west highway of the world.

The Far East. From Iran eastward to the shores of California there are few oil fields of outstanding importance. All the countries of the Far East account for only 2% of the world's known oil reserves and for about 2½% of the world's production. In both respects, Africa and Australia are much poorer.

Indonesia is by far the leading oil producer in the Far East, its output amounting to over 75 million barrels a year. The chief fields are the Palembang, Djambi, and Pladju fields of Sumatra and the newly developed Klamono field on the Vogelkop Peninsula of New Guinea.

Oil fields along the coast of Sarawak and Brunei (British Borneo) rank second among Far Eastern producers, the Borneo output amounting to 37 million barrels in 1953, a fivefold increase since 1939. In contrast, the Yenangaung and Chauk fields of the Irrawaddy Valley in Burma now yield only 1 million barrels a year, or about one eighth of their prewar output. Again, diminishing returns and exhaustion are the ultimate fate of every oil field.

5. PETROLEUM REFINING, TRANSPORTATION, AND TRADE

Improvements in refining. Two years before Drake drilled his famous well, petroleum refining was born at Yale University when Benjamin Silliman, Jr., discovered that the

[10] The sheikh's income amounted to $30 million in 1951 and is estimated to be about $160 million in 1952. See Edwin Muller, "Croesus of Kuwait," *The Reader's Digest,* July 1952, pp. 73–80.

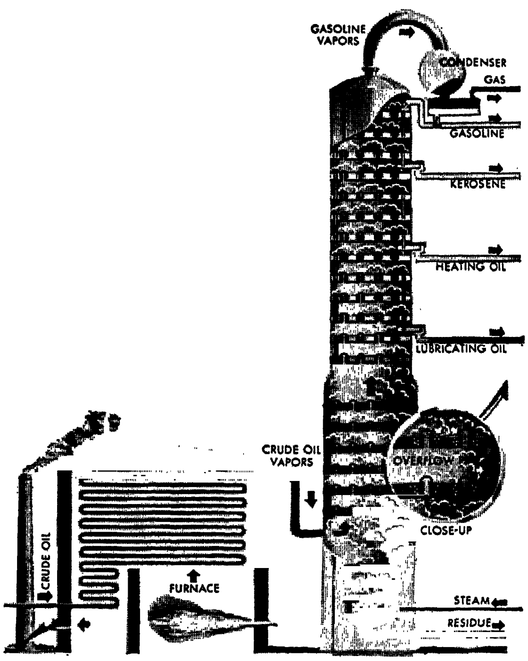


Diagram to illustrate fractional distillation. Residue asphalt or wax. ***American Petroleum Institute***

specimen of "rock oil" that had been sent to him from western Pennsylvania was a complex hydrocarbon compound that could be separated easily by simple distillation into products that could be used for illumination, lubrication, and other purposes.[11]

In the simplest form of distillation the crude oil is put in a large tank and heated so that one product after another becomes volatized and passes off, like steam from a kettle, to be caught and condensed. The application of heat at first drives off the lightest products—the gases, naptha, and gasoline. As the heat is increased, heavier products are obtained, such as kerosene, fuel oil, lubricating oil, and finally heavy residual oil, wax, asphalt, and coke. Each product is capable of separation into others by redistillation, and every year more and more products are derived from petroleum.

Distillation can separate crude oil into its fractions, or component parts, but it cannot obtain more of a particular fraction than nature put there. Since the advent of the automobile and the airplane and the development of high-speed and high-compression motors, the major problem of the petroleum chemist has been to obtain more and better gasoline from each barrel of oil.

Fortunately, new processes have made it possible to get more gasoline from crude oil. Simple distillation was replaced by a continuous and more effective process known as straight-run refining, which in turn was surpassed by thermal cracking. Whereas simple distillation seldom yielded more than 10% gasoline and straight-run refining seldom more than 25%, thermal cracking makes possible the recovery of 65%. Catalytic cracking is even more effective and threatens to displace thermal cracking. Indeed, the use of hydrogenation, in conjunction with cracking and polymerization, now makes possible the complete conversion of crude oil into motor fuel.[12] The work of the chemist with petroleum is almost a realization of the medievalist's idea of alchemy.

[11] National Resources Committee, *Technological Trends and National Policy,* Washington, 1937, p. 157.

[12] In *simple distillation* the crude oil is placed in a single tank, where all evaporation takes place. In *straight-run refining* crude oil passes through a series of tanks, each having the proper temperature to evaporate one set of hydrocarbons. In *thermal cracking,* the gas-oil distillate, once a drug on the market, is subjected to great temperature and pressure and is broken down into gasolines of higher antiknock qualities. *Catalytic cracking* produces gasoline by heating either crude oil or gas-oil distillate and passing the vapor through a catalyst under conditions of relatively low pressure and heat. *Hydrogenation* goes farther than cracking; it also breaks down the heavy hydrocarbon molecules under great pressure and heat, but it makes use of a catalyst to inject hydrogen into the newly created molecules, which improves the quality of the gasoline and builds up the quality of all the oil that is used. *Polymerization* is essentially the reverse of cracking, for it combines small molecules into larger ones which can then be condensed into liquids. By controlled heat and pressure, polymerization converts the light gases from petroleum refining into high-octane blending agents for motor gasoline. See Schackne and Drake, *op. cit.,* pp. 57–72, and Evan B. Alderfer and Herman E. Michl, *Economics of American Industry,* McGraw-Hill Book Co., New York, 1950, pp. 279–281.

Because of the availability of new processes, the yield of gasoline per barrel of crude oil in this country has increased from 18% in 1914 to 44% at the present time. With each passing year, the world is supplied with more and better motor fuel. With its new techniques, the refining industry stands ready to supply virtually any petroleum product in any proportion from any grade of crude oil. This means a more effective use of an exhaustible natural resource.

Size and location of refineries. The world's leaders in petroleum refining today are the United States, the West Indies, the Soviet Union, the United Kingdom, Iran, Canada, and France. At the end of 1953, there were 662 refineries, with a total crude oil capacity of 23½ million barrels daily, operating in widely scattered parts of the world.[13] Of these, 320 were located in the United States, accounting for 60% of the world's refining capacity. American refineries vary in capacity from less than 500 to 235,000 barrels daily. They are not so large as the giants of Aruba, Curaçao, and Abadan.

The modern refinery costs millions of dollars. Capital costs are tremendous not only because of the huge investment in expensive equipment but also because the equipment depreciates rapidly under the continuous high temperatures and pressures that are used. Rapid changes in the technology of refining make equipment obsolete and the purchase of new equipment necessary within a few years. Large sums are spent on research, without which the industry would stagnate. Labor costs, however, account for only 6% of the value of the total product, because operations are so mechanized that about the only manual labor needed is that of maintenance and repair crews and men who read the gauges and manipulate the valves and pumps.

The location of refining is the result of a delicate balance of forces involving nearness to market, nearness to raw material, and the availability and cheapness of transportation. A large part of the world's refining capacity is located along the northeastern seaboard of the United States and the coast of northwestern Europe. Such seaboard refineries are close to huge markets, and the cheap tanker can bring crude oil from any port on the world ocean.

Almost equally advantageous are seaboard refineries located on the edge of oil fields, as along the coasts of Texas, California, the West Indies, and the Middle East. They ship their products cheaply by ocean tanker and are able to reach a variety of markets.

Refineries in such cities as Cleveland, Chicago, and St. Louis are primarily market refineries, since their chief advantage is a short rail or truck (chiefly truck) haul in the distribution of finished products to important markets nearby. Field refineries, far removed from both navigable water and major markets, have the greatest disadvantage, for they are restricted to local markets, unless crude oil and refining costs are low enough to warrant the shipment of their products by pipeline or tank car to distant markets.

Improvements in transportation. Two important geographical facts account for the development of large-scale transportation of crude petroleum and the products that are refined from it. First, very few oil fields are located near the densely populated, highly industrialized areas that comprise the leading markets for petroleum and its products. Second, the great bulk of the world's crude oil is produced in a few regions, whereas virtually every nation consumes petroleum products.

In the years that followed Drake's discovery of oil, petroleum was carried in kegs and barrels by whatever mode of transport was available, which sometimes involved carriage on horseback, in wagons, flatboats and barges, and railway cars before the oil reached the refinery, and from there the finished products were delivered to the consumer in barrels. The labor and expense of moving petroleum in barrels soon led to improved methods of transportation. The first pipeline was laid in 1862,

[13] Duff, *op. cit.*, pp. 117–118.

and by 1874 pipelines had reached Pittsburgh. Wooden tank cars were first used on the railroads in 1865, but they were soon superseded by larger and better tank cars made of steel. On the high seas the movement of petroleum and its products in barrels gave way to shipment in 4-gallon square tins or cases, which in time gave way to specially built tank ships holding thousands of barrels.

The U. S. petroleum industry is served by a vast transportation system consisting of 280,000 miles of pipelines, over 100,000 railway tank cars, some 2000 barges and small tank vessels on our inland and intercoastal waterways, more than 500 ocean tankers under the American flag, and many thousands of tank trucks.[14] All these were needed to move 2½ billion barrels of crude and refined products within a single year.

No nation has such an extensive system of pipelines (see Fig. 312 top). Of our pipeline mileage, about 40% consists of small gathering lines that bring oil from the individual wells to central storage points or directly into main trunk lines; nearly 47% consists of crude-oil trunk lines that lead to the nation's refineries and storage tanks; and 13% consists of products lines that carry gasoline, kerosene, fuel oil, and other products from the refineries to major distribution centers. The main pipelines are steel pipes, 8 to 24 inches in diameter, through which oil is moved at the rate of about 3 or 4 miles per hour by the pressure created by Diesel engines or electric pumps, which are spaced at 35 to 75 mile intervals.

It is estimated that the cost of transporting 1 ton of crude oil 1 mile is 4.87¢ by motor truck, 0.83¢ by railway tank car, 0.32¢ by pipeline, less than 0.2¢ by barge, and only 0.12¢ by ocean tanker.[15] Since the bulk of our petroleum is produced in the Midcontinent and other interior fields, pipeline transportation is indispensable. Indeed, pipelines deliver more than 80% of the crude oil that is received by our refineries each year from American oil fields. Tank trucks and railway tank cars are used primarily in the distribution of refined products.

World trade. In spite of important changes since 1939, today's overseas trade in petroleum resembles prewar trade in several fundamental respects. First, less than 40% of the world's annual output of petroleum enters into the channels of international trade, because the United States and the Soviet Union are not only the first and third largest producers but also the two largest consumers. Second, the great bulk of all exports move to the oil-poor countries of western Europe. Third, with the exception of the United States, the leading exporters are nations with small domestic markets, such as Venezuela, Saudi Arabia, Kuwait, Iraq, and Colombia. Fourth, the prewar tendency to refine crude oil prior to exportation continues to increase.

Among the significant changes in the prewar pattern of petroleum trade is the Middle East's surpassing of the Caribbean area as the world's greatest petroleum-exporting region. The United States, in spite of its huge production and sizable exports, has become a net importer of petroleum and is drawing heavily upon Caribbean oil to augment its supply. The great bulk of Caribbean exports now move to the United States instead of Europe. The nations of western Europe now obtain more than four fifths of their petroleum supply from the Middle East.

For many years petroleum products have been consumed in virtually every nation of the world. The wide distribution of petroleum products is well illustrated by the sale of kerosene. It goes alike to Greenland and New Zealand, Norway and Madagascar, to the tribesmen in East Africa, to the Spaniard in Spain and the Spanish-speaking *mestizos* of the Philippines. The Chinese, who regard light as a most prized luxury, in normal times buy large quantities of kerosene. The ordinary 4-gallon cans of kerosene are distributed

[14] See C. R. Musgrave, *The Development of Transportation by the Petroleum Industry and Its Contribution to the National Welfare,* Transportation Association of America, Chicago, 1952.

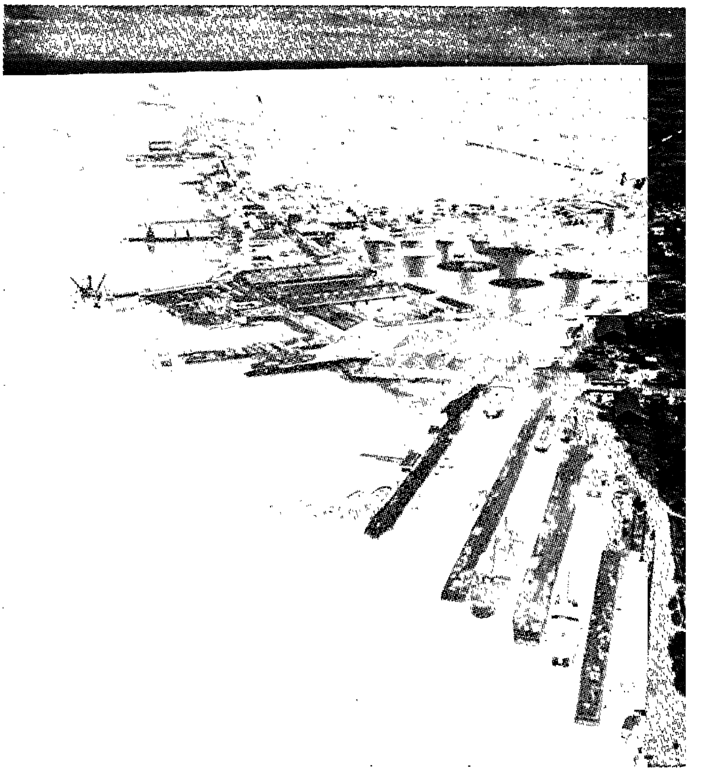
[15] Pratt and Good, *op. cit.,* p. 146.

throughout the interior of China in places where the face of the white man has never been seen. And the empty oil can! What services does it not render, from house roof to city water supply (by way of vendors)?

6. SUBSTITUTES FOR PETROLEUM

Oil shale. As the day of petroleum exhaustion draws nigh, man will be forced to turn to a diligent use of substitutes. One is oil shale, a rock that holds in its pores an organic substance known as kerogen. When heated, kerogen turns into a thick oil that can be converted into gasoline, fuel oil, Diesel oil, kerosene, and other products. Some shales yield less than 5 gallons of oil per ton, while others yield over 50.

The shale-oil industry is by no means new. The French were recovering oil from shale as early as 1838; the Scotch, in 1850. Shale oil is produced in Great Britain, South Africa, France, Sweden, Spain, and other countries.[16] It is believed that the Russians are now producing as much as 2 million tons of shale oil a year, their chief deposits being located along the Volga, in the Leningrad district, and in Estonia.[17]



Mactan Island, near Cebu, P. I. Oil in by tanker, out by tin, drum, small bulk boat, truck, and cart. *Standard Oil Company of New Jersey*

While oil-shale formations exist in many parts of the United States, the largest deposits are concentrated in northwestern Colorado, northeastern Utah, and southwestern Wyoming. The shale beds of Colorado are the thickest, richest, and most easily mined. It is estimated that the shale deposits near Rifle, Colo., capable of yielding 30 gallons of oil per ton, are large enough to provide at least 80 billion barrels of liquid fuels, while other deposits of lower grade could produce an additional 420 billion barrels.[18] In contrast, our proved petroleum reserves in 1953, amounted to 29 billion barrels.

Unfortunately, the oil-shale deposits of the Rocky Mountains lie remote from major markets. As yet the production of shale oil in the United States remains in the experimental stage. Oil shale is being mined at Rifle under the auspices of the U. S. Bureau of Mines. Experimental plants for the recovery of shale oil have been established at Rifle, at Baton Rouge, La., and elsewhere. Processes developed by the petroleum industry and the federal government can now produce liquid fuels from shale comparable in quality to petroleum products. Oil from shale may come into commercial production within a decade or two, or perhaps sooner.

Liquefaction of coal. At present coal is much more important than oil shale as a source of oils and gasoline. Gasoline obtained from the liquefaction of coal costs between 17¢ and

[16] Production in thousands of metric tons in 1952: United Kingdom, 108; Union of South Africa, 36; Sweden, 40 (1951 data); France, 22; Spain, 8. U. N., *Statistical Yearbook, 1953,* p. 110.

[17] Pratt and Good, *op. cit.*, p. 237.

[18] The President's Materials Policy Commission, *Resources for Freedom,* Washington, 1952, Vol. 1, p. 109.

25¢ per gallon at European plants in 1937, in which year Germany was able to obtain 30% of her gasoline from coal.[19]

The Germans have led the world in the production of gasoline from coal. In 1951 it was reported that the Russians were supplementing their petroleum supply by making 50,000 barrels of synthetic gasoline a day.[20] In a demonstration plant at Louisiana, Mo., the U. S. Bureau of Mines has produced good gasoline from coal at a cost of 8¢ to 10¢ a gallon, after allowing credit for the sale of by-product chemicals.[21] Coal is by far the world's largest potential source of motor fuel.

Benzol and alcohol. Benzol is another substitute for gasoline that is recovered as a by-product of coke production, low-temperature coke ovens yielding about two thirds of a barrel of oil from a ton of coal. The Germans have produced a part of their synthetic gasoline by this method. The world's total output of benzol, however, could supply only a tiny fraction of the world's voracious and increasing demand for motor fuel.

Alcohol derived from the world's abundant supply of grain and sugar cane can be used as fuel in internal combustion engines, and in many oil-poor countries it is mixed with gasoline. Indeed, there is no technical reason why synthetic gasoline cannot be obtained from sawdust, cornstalks, or garbage, but large-scale production costs would be prohibitive at present.

The greatest problem confronting man when the day of petroleum exhaustion arrives will be the problem of lubrication. Castor oil is used as a lubricant for airplane motors, because of its resistance to heat. It and other vegetable oils can be used for special lubricating purposes, but as yet there is no good general substitute for petroleum oils and greases. Perhaps the chemist with his new technique of recombining molecules, called polymerization, will find the answer, but even he will need raw materials.

7. NATURAL GAS

United States production. The commercial production of natural gas in the United States began in 1820, when gas was conveyed from a shallow well through a lead pipe to 30 domestic consumers in Freedonia, N. Y. In 1872 gas was piped into Rochester, N. Y., and Titusville, Pa. From an output of about 2 billion cubic feet in 1880, production in this country has increased to 9239 billion cubic feet in 1953 (see Fig. 327).

For many years the distribution of gas did not exceed a radius of 100 to 250 miles, but the discovery of huge gas fields in Louisiana, the Texas Panhandle, and elsewhere was followed by the construction of welded pipelines, 18 to 30 inches in diameter, capable of transporting gas under high pressure with negligible loss for 1800 miles or more (see Fig. 312 bottom).

Today the nation is served by a network of over 300,000 miles of pipelines that gather, transmit, and distribute the gas of 27 states to customers located in every state except Maine, Vermont, Nevada, Idaho, Oregon, and Washington. Erelong our Northwest will be served with gas from Texas and Alberta.

While gas is found in many areas that do not produce petroleum, approximately one third of the natural gas in this country is produced in conjunction with petroleum, and it separates itself from oil as cream separates from milk. Hence, while the major natural gas and petroleum-producing regions are coterminous, many gas fields lie outside specific petroleum-producing areas. Yet the relationship between petroleum and natural gas is close, for the Midcontinent, Gulf Coast, and California regions contain more than 90% of the nation's proved gas reserves, and in 1953 the great oil-producing states of Texas, Louisiana, Oklahoma, and California produced 81% of the nation's supply of natural gas.

In the earlier years of the industry, the chief function of gas was to raise petroleum to the

[19] National Resources Committee, *Energy Resources and National Policy*, Washington, 1939, p. 322.

[20] Carmical, *op. cit.*

[21] Bituminous Coal Institute, *1951 Bituminous Coal Annual*, Washington, 1951, p. 179.

19· Water Power—A Permanent Resource

1. THE SIGNIFICANCE OF WATER POWER

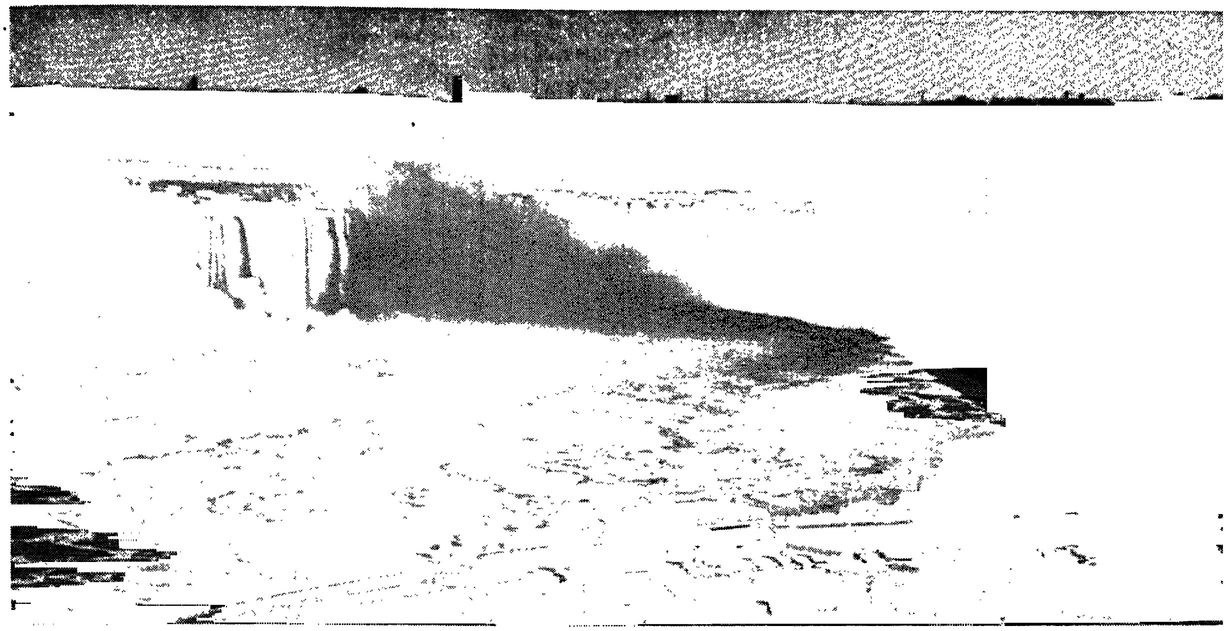
A perpetual source of energy. Coal and oil and gas in time will go, but water power will remain. As long as the rains and snows from heaven fall upon this earth, as long as water runs down to sea to be lifted by the sun through evaporation and wafted over the lands to start its journey anew, man will have at his disposal a perpetual source of power. Water power is a form of perpetual motion, like the movement of the moon and other planets.

Water is wasted if not used, and to use it is to conserve it. Wise are those nations that make intensive use of water power, supplementing it with their exhaustible supplies of mineral fuels. From the viewpoint of permanency, water power has no rival among the great sources of energy used by man today.

Popular misconceptions. The average American mind holds many erroneous ideas about water power. Probably the most popular misconception is in regard to its importance. Many people assume that virtually all our electricity and most of our energy supply are derived from water power, and that there is plenty of it. The fact is that only 24% of the electric energy produced in the United States is now generated by hydroelectric plants, the remainder being generated by plants using coal, natural gas, and oil (see Fig. 287 right). Indeed, it has been estimated that if every drop of water falling as rain in the United States could be transformed into power at existing gradients, the supply of energy would not equal that derived in most years from coal.[1] Furthermore, it is probable that less than one tenth of the world's total daily output of work is accomplished by the use of water power (see Tables 2:2 and 17:1).

A second misconception concerns the cheapness of water power. Many people believe that simply because it rains and water runs downhill, water power is a free gift of nature and is very cheap. True, water power is a gift of nature, but so are coal, oil, and gas, and all require the expenditure of capital and labor before they can be of service to man. Hundreds of millions of dollars are spent in the construction of dams alone, Grand Coulee costing $111,150,000. Capital costs for hydro plants are much higher than for thermal plants, although operating costs are much lower. Although the nation-wide average cost of hydroelectricity is now less than that of thermal generation, there are many areas where elec-

[1] It is estimated that if the entire run-off of water could be put to work, water power would yield the energy equivalent of 437 million tons of coal. National Resources Committee, *Energy Resources and National Policy*, Washington, 1939, p. 56. From 1940 to date our total coal output has exceeded 500 million tons in every year except 1949 and 1953.



Niagara Falls—87,600 square miles of natural reservoir (Great Lakes) and a precipice make a power site par excellence. Keeping the great spectacle wastes a lot of power. Powerhouse right center. Power 1st magnitude. *Hydro-Electric Power Commission of Ontario*

tricity from coal, oil, and natural gas is cheaper, and there are only a few regions that can count on substantial increases of relatively low-cost hydroelectricity in the future.[2]

A third popular fallacy exists regarding the transportation of power. Many people think that only poles and a power wire are needed to convey electricity from the hydroelectric dam to any spot where it may be needed. As a matter of fact, the practical transmission of large blocks of power is restricted at present to a radius of about 300 miles. Hydroelectric energy must be produced at the water-power site, whereas the mineral fuels can be transported to power plants located in the midst of the market.

2. THE POTENTIAL SUPPLY OF WATER POWER

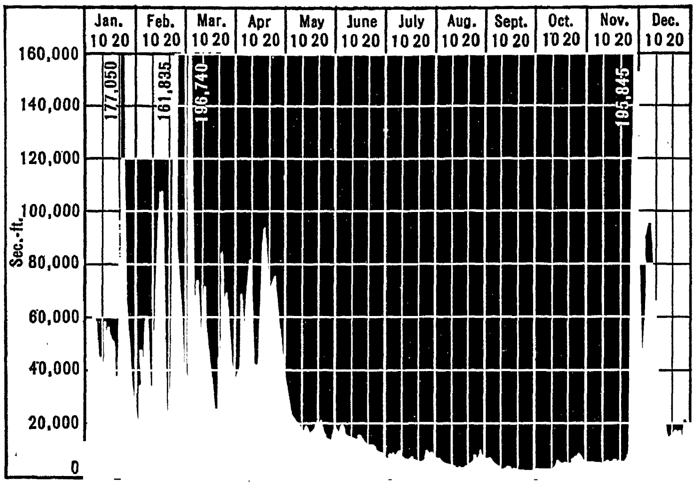
Water-power prerequisites. In order that the rivers of a region may offer a large and dependable supply of water power, three conditions are necessary: (1) there must be abundant precipitation, (2) stream-flow must be uniform, and (3) there must be sufficient slope or gradient to provide a good head or fall of water. These three conditions are found on the largest scale in Africa, which has 41½% of the world's *potential* water power (see Table 19:1). Africa is not the largest or the most mountainous continent, but it contains the largest area of high land within the

TABLE 19:1. Potential and Developed Water Power of the World, by Continents, 1950
(millions of horsepower)

Continent	Potential water power[a]	Capacity of water-power plants
Africa	272.0	.6
Asia	151.0	13.7
North America	87.0	41.1
Europe	69.0	40.8
South America	55.0	3.1
Oceania	23.0	1.4
World total	657.0	100.7

[a] Based upon ordinary minimum flow, or the stream-flow for 95% of the time.
Source: U. S. Geological Survey, *Developed and Potential Water Power of the World,* mimeographed bulletin, Washington, 1951, p. 7.

[2] The President's Materials Policy Commission, *Resources for Freedom,* Washington, 1952, Vol. 1, pp. 117, 119. This report would interest many readers of this book.



Flow of water for one year at Harrisburg, Pa., shows what a lakeless river does even when more than half the basin is forested. A few hundred square miles of reservoir would do midsummer wonders. *U.S. Geological Survey*

zone of heavy tropical rainfall, and hence the great African rivers, especially the mighty Congo, offer the world's greatest supply of water power.

Environment and stream-flow. The amount, character, and distribution of precipitation are of vital importance in determining the water-power potentialities of any region. There is no water power in a riverless desert unless a stream like the Nile or Colorado flows into it. Thus the site of the gigantic power-producing Hoover Dam is the Black Canyon of the Colorado River in the heart of the Great American Desert, but the headwaters of the river are fed by rain and snow on distant mountains.

The character of precipitation is often as important as its volume. The lofty Sierra Nevadas of California get most of their moisture as winter snow. It takes time for snow to melt; some water soaks slowly into the soil and reappears gradually in springs and mountain streams. The result is less seasonal variation in stream-flow than would be the case if the precipitation were in the form of rain. Unfortunately, the amount of snowfall varies greatly from year to year.

None of the world's rivers has a perfectly uniform stream-flow season by season and year by year, and most rivers are not ideal. Monsoon lands of southeastern Asia receive their rain in summer, and in winter many rivers run dry, while in Mediterranean lands opposite conditions prevail. Even the mighty Amazon, flowing through rain-drenched jungle, has its flood seasons. Because of seasonal and annual variations in stream-flow, dams and reservoirs are often needed to store water.

In some areas nature helps to provide water storage. The spongy leaf mass of the forest floor holds water and makes more even stream-flow and better water power on a forest stream than on one draining tilled lands or hard-tramped pastures. Porous volcanic soils, such as those parts of our Cascade Mountains, are splendid. So are swamps and marshes, and lakes are best of all.

Man improves streams by building dams to serve as reservoirs and hold the water, but the natural reservoirs of lakes are manyfold better and hold water that would otherwise be wasted in freshets, to let it out in time of drought. As most of the world's lakes are due to the action of glaciers, the fact that an elevated region has been glaciated is, granted rainfall, a most important thing in deciding its water-power resources. The St. Lawrence River system is the crowning example of this. The Niagara River, with its wonderful natural reservoirs, varies but little in volume, while the lakeless Susquehanna varies according to the amount of rainfall from 5000 to 196,000 cubic feet per second (see Fig. 330).

Snowfields and glaciers are second to lakes

as natural reservoirs, and they have the particular advantage of releasing the water in time of summer drought and holding it tight in a period of excessive winter precipitation. Abundant rainfall and good natural storage facilities give the Pacific Northwest the largest potential water-power resources of the United States. Norway, Sweden, and Switzerland have a similar advantage.

Temperature also affects a region's supply of water power. In areas that have long and cold winters, as in Siberia, the Yukon valley, and northern Canada, many a river freezes solid for months. At such times the water course breaks out through some weak place and flows along the top of the stream, freezing and piling up great masses of ice and flowing about in devious ways to escape its own obstructions. If the land is fairly level, the water-power supply is dissipated with the icy floods that inundate the countryside. If the stream flows through a narrow gorge, great ice jams are formed that hold back the water. When the thermometer remains at 30°, 40°, or 50° below zero for weeks at a time, stream-flow is reduced, especially in the upper course and small tributaries. Extremely cold temperatures for prolonged periods of time resemble drought in power to injure a dependable, year-round water-power supply.

The topographic factor. In the early years of water-power development, little waterfalls in small streams were prized power sites that could be easily used by the simple water wheel for local service. Gigantic waterfalls were scenic wonders of varying usefulness for power production. Today, in an era of turbines and dynamos, a large volume and big head of water are prerequisites for maximum production of hydroelectric power. Among the specific power sites of the world, few are as ideal as Niagara Falls where, with four of the Great Lakes as a vast reservoir, a large and steady volume of water drops 327 feet through penstocks (large pipes) and turbines to generate electricity.

Many a mountain stream, small in volume but with a tremendous drop of water, has been harnessed for power since the advent of the turbine and the even swifter pelton. Rugged lands have become important producers of hydroelectric power, such as Norway, Switzerland, Italy, Japan, the east central plateau of Brazil, and California. In contrast, the flat lands of Denmark and Florida rank low in potential and developed water power.

Natural reservoirs on glaciated upland U. S. Upper Lake Region and Laurentian Plateau to Coast Labrador and Mackenzie Valley. ***U. S. Forest Service***

Among the great river systems of the world, the grand prize in water-power creation seems to be the combination of conditions that prevails on the Congo. (See potential resources of French and Belgian Congo, Table 19:2.) This river runs east and west along the Equator in such a position that the doldrum rains fall continually on its northern branches, its sources, or its southern branches, thereby causing it to miss the great seasonal fluctuation common to most great rivers. Unlike the placid Amazon, which drops only 35 feet in its last 1000 miles, the Congo kindly tumbles some 3000 feet in a series of cataracts near its mouth, making water-power resources so stupendous as to be severalfold those of any other continent. Stanley Falls on the middle Congo, with its seven cataracts, is estimated to have 10 to 15 million horsepower, but the problem of developing it involves much difficult engineering.

TABLE 19:2. Potential Water Power in 20 Leading Countries in 1950

Country	Millions of horsepower[a]
Belgian Congo	130.0
U. S. S. R.	78.0
French Congo	50.0
India, Pakistan, and Ceylon	39.0
United States	36.2
Canada	33.5
China	22.0
French Cameroons	18.5
Brazil	16.0
Nigeria and British Cameroons	13.0
Borneo, New Guinea, and Papua	10.5
Norway	10.0
Mexico	8.5
Japan	7.2
Madagascar	7.0
British East Africa	6.7
Peru	6.4
France	6.0
Italy	6.0
Indochina	6.0

a Based upon ordinary minimum flow, or the stream-flow for 95% of the time.
Source: U. S. Geological Survey, *Developed and Potential Water Power of the World*, mimeographed bulletin, Washington, 1951, pp. 4–7.

It is clear, therefore, that the amount, character and seasonal distribution of precipitation, the range of temperature, the type and extent of vegetal cover, and topographic, hydrographic and soil conditions vary greatly among different countries and regions, but that each of these factors has an important effect upon the potential supply of water power in any area.

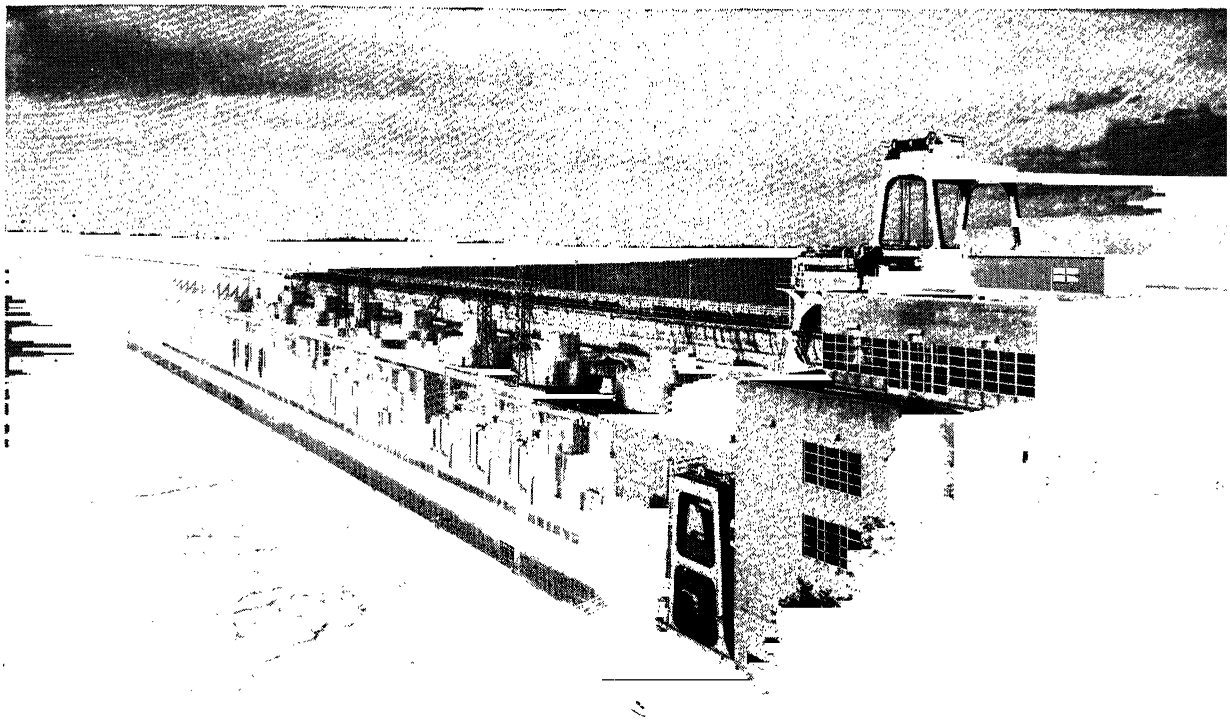
3. THE DEVELOPMENT OF WATER POWER

Early development in the United States. The use of water power has had its ups and downs, depending on industrial conditions and inventions. It was a factor of great importance in the American Colonies, furnishing as it did a means to grind their flour and saw their logs, a thousand little mills in a thousand neighborhoods. Largely because of its splendid water-power resources, New England became the cradle of the Industrial Revolution in America. Factories using the new power-driven machinery developed and thrived alongside the comparatively small waterfalls of New Eng-

TABLE 19:3. Capacity of Water-power Plants in 20 Leading Countries in 1950

Country	Total capacity in millions of horsepower	Horsepower per capita
United States	27.5	.18
Canada	12.6	.90
Japan	9.2	.11
Italy	8.5	.19
France	7.2	.17
U. S. S. R.	4.3	.02
Sweden	4.1	.60
Norway	3.9	1.30
Switzerland	3.9	.80
Germany	2.7	.04
Spain	2.3	.08
Austria	2.0	.30
Brazil	1.9	.04
Korea	1.8	.06
India, Pakistan, and Ceylon	0.9	.02
United Kingdom	0.8	.02
New Zealand	0.7	.35
Finland	0.7	.18
Australia and Tasmania	0.4	.05
Chile	0.4	.07

Source: Total capacity data from U. S. Geological Survey, *Developed and Potential Water Power of the World*, mimeographed bulletin, Washington, 1951, pp. 4–7. Per-capita data were computed by the authors.



Wheeler Dam in northern Alabama—72 feet high, 6342 feet long, 8 turbines. Power 2d magnitude. Compare little country *overshot* wheel (p. 27). Wheeler will do more work than 50,000 such. Each turbine is rated 45,000 h.p., 32,400 kw. *Tennessee Valley Authority*

land, the Mohawk Valley, the Fall Line, and other propitious water-power sites. Indeed, as late as 1869 one half of all the power used by American industries was water power.

As the steam engine invaded U. S. industry, the old-fashioned overshot water wheels so common from 1650 to 1850 were largely displaced in the latter half of the nineteenth century by improved engines and cheap coal. Small country mills were abandoned by the thousands as a result of this change, and in 1900, of the total energy obtained from the mineral fuels and water power, 89% was derived from coal.

Revolutionary improvements. With the perfection of the steel-reinforced concrete dam, the hydraulic turbine, and the dynamo, water-power development throughout the world entered a new epoch. The use of Portland cement in the construction of dams not only increased the height of fall, or head of water, at a given site but also made possible the storage of water during periods of heavy rainfall for later use in times of drought, thereby reducing the handicap of erratic stream-flow. Furthermore, the construction of giant dams and reservoirs has often increased severalfold the amount of power available from natural stream-flow at specific power sites. For example, storage provided by the 553-foot dam at Grand Coulee made available 6.8 times as much power as could be obtained from natural stream-flow.[3]

The modern hydraulic turbine, using the great pressure of water dropping through penstocks, or large pipes, has made possible the utilization of any volume of water and a fall of several hundred feet, thereby making available for power production such great waterfalls as Niagara. The dynamo, turned by a shaft rotated by water flowing through the turbine, generates electricity which can be transmitted several hundred miles, thereby

[3] National Resources Committee, *op. cit.*, p. 238.

liberating the power consumer from the necessity of locating his factory or mill at the power site. The significance of these three great technological improvements to our water-power industry is evidenced by the fact that the installed water power in this country has increased from about 2 million horsepower in 1900 to 10 millions in 1920, and to 22 millions in 1953 (see Fig. 287 right).

Other advances. While the water-power industry was revolutionized by the advent of the concrete dam, hydraulic turbine, and dynamo, other improvements have added greatly to its efficiency. It was soon discovered that a large central generating plant can produce electric energy for a given area far more cheaply than a number of small private plants, and this gave rise to a separate power industry selling electricity to ever-increasing numbers of industrial and domestic consumers.

Later it was found that many advantages are to be derived from interconnection of many central generating stations, including both hydroelectric and thermal plants, which helps to reduce the cost of electricity and to increase the reliability of service. The most efficient plants can be operated full time, the less efficient plants being called into service to meet peak demands. When a severe drought or seasonal water shortage occurs, causing a curtailment or cessation of hydroelectric production, power can be supplied from more fortunate areas.[4] Again, interconnection provides insurance against the inconvenience caused by the accidental breakdown of any plant belonging to the system, because the stricken plant can draw upon outside power. Then, too, the interconnection of hydroelectric and thermal plants makes possible a more frugal use of coal, oil, and gas in electric-power production, at least in those areas where mineral fuels are more expensive. Finally, it may be noted that a superpower system, pooling the resources of many generating plants, often serves a large area involving a diversity of consumers. Since the bulk of industrial demand comes in the daytime and since domestic consumers use most electricity for light at night, a diversified demand permits a fuller use of generating facilities throughout the 24 hours of each day.

Since World War I there has been a widespread development of superpower systems in this country. One of the largest is the 17-state southeastern power pool extending from the Gulf of Mexico to the Great Lakes. Another on the Pacific Coast links many of the power plants between the Canadian and Mexican borders.

Today large blocks of power, ranging up to 287,000 volts, are transmitted economically over a radius of 250 to 300 miles, and the Bonneville Power Administration is now contemplating a 600-mile transmission line. Every improvement in transmission technique is of special importance to the hydro plant, which must generate its electricity at the water-power site.

Economic factors affecting development. Whether potential water-power resources will be developed or not in a given area depends largely upon two economic considerations, namely (1) the present and estimated future market demand for power and (2) the present and future competition from other fuels. These two economic factors go far to explain the present distribution of the world's developed water power (see Tables 19:1, 19:3, and 19:4).

The great bulk of the world's water power has been developed to date by private enterprise, whose sole aim is to reap the maximum profit. In the United States private enterprise now produces 85% of the nation's electric energy.

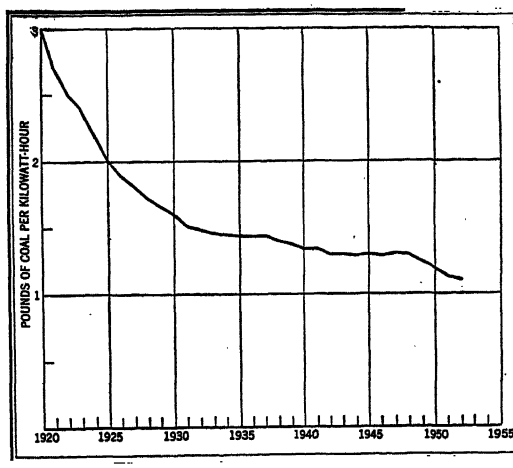
In the case of governmental enterprise, the profit motive is not dominant or may not even

[4] In northern Italy, around Genoa, an interconnected system of hydroelectric plants secures its power chiefly from the Alps in the summer and fall, when Alpine snow and ice are melting, and chiefly from the Apennine Mountains in winter and spring, when the Italian peninsula receives its maximum rainfall. Erich W. Zimmermann, *World Resources and Industries*, rev. ed., Harper & Brothers, New York, 1951, p. 580.

exist. The government is able to wait a long time for a return on its investment and is able to take a chance that a future market for power will arise after the plants have been created. Indeed the market demand for power may not be the sole or major consideration, as the government may wish to provide the people with such services as irrigation, navigation, and flood control, which often require large-scale reforestation and soil-conservation programs. The government is better able to develop the entire water resources of a river basin than any private corporation. It is scarcely conceivable that private enterprise could ever have undertaken such gigantic projects as TVA, Hoover Dam, Grand Coulee, and Bonneville, and history will probably record that they were well worth the cost.

Throughout the world governmental projects are steadily increasing. While the government is not bound by short-run monetary calculations, it is or should be interested that each project, considered in view of all services rendered, will yield during the life of the project an adequate return to the people on the investment of taxpayers' money. In planning a project, the government must consider present and future market demands and the availability of competitive fuels, for these two factors determine the economic practicability of water-power development.

Water-power development in Europe. North America and Europe far surpass all other continents in the development and use of water power (see Tables 19:1 and 19:4). North America has about 13% of the world's potential water power, and Europe has 10½%, yet each continent possesses about 40½% of the total capacity of water-power plants. In contrast, Africa, with 41½% of the world's potential supply, accounts for less than ½ of 1% of the developed power. Indeed, the whole of Africa has less developed water power than Finland, but large new plants seem imminent on branches of the Zambezi to make power for copper mines.



The carbo-electric plant is more efficient than most water-power sites today. ***U. S. Bureau of Mines***

The facts cited above and the striking contrasts revealed by Tables 19:1, 19:2, and 19:3 clearly indicate that there is little correlation between potential and developed water power. Natural environment is no resource unless it actually functions in the service of man. Human wants, human abilities, and type of civilization go far to explain the leadership of North American and European peoples in the development and use of water power.

Italy, Norway, Sweden, and Switzerland together possess about one half of the developed horsepower of Europe, Norway leading the world in water-power development per capita. Each of these countries is virtually destitute of mineral fuels, and each has a well-developed industrial demand for power along with stable, honorable, and liberal governments. The most intensive use of available water-power resources is found in Germany and Italy, the installed capacity of water wheels exceeding the potential power available under conditions of minimum stream-flow.[5]

The leading manufacturing nations of Eu-

[5] The storage of water behind great dams makes it possible for many hydroelectric plants to have and to use an installed capacity two or three times larger than the amount of power existing under conditions of minimum stream-flow, or the power naturally available 95% of the time.

rope, however, are Great Britain, Germany, the Soviet Union, and France, which are important producers of coal, and each depends predominantly upon coal as a source of energy. In Great Britain, where coal is plentiful and potential water-power resources are comparatively small, hydroelectric projects are of limited importance. In Germany the huge industrial demand for power has led to an intensive use of all available power resources, including coal, lignite, and water power. The Soviet Union, an industrial newcomer that is rich in coal, oil, gas, and water power, has only begun to utilize her potential water-power resources. France makes great use of water power, since nearly one third of her annual coal supply must be imported. The demand for power in highly industrialized and urbanized sections of western Europe is tremendous, and in those countries lacking mineral fuels water power plays its most important role.

TABLE 19:4. World Production of Hydroelectric Power
(billions of kilowatt-hours)

Continental area	1929	1937	1950
North America	50.9	72.4	145.8
Europe	43.0	65.0	112.1
Asia	13.9	26.5	47.7
U. S. S. R.	.04[a]	5.8	10.6[b]
Latin America	2.2	4.8	10.3
Oceania	0.9	1.7	4.5
Africa	0.1	0.5	1.3
World total	111.4	176.7	332.3

a Data as of 1930.
b Scheduled output in 1940, which, because of subsequent war damage, is taken as representing output in 1950.
Source: United Nations, *Monthly Bulletin of Statistics,* Vol. 6, February 1952, p. xvi.

Water-power development in North America. In North America the greatest development of water power has occurred in eastern United States and the southern parts of Quebec and Ontario in Canada, for here, as in western Europe, are to be found the greatest density of population, development of manufacturing, and demand for power. The most intensive use of water power is in New England, where manufacturing began with the use of water power as we have noted. Like Italy, New England has long been dependent upon imported coal. In coal-poor Quebec and Ontario, as in Norway and Sweden, great pulp and paper and huge electrochemical industries have been developed, and these require vast amounts of cheap electric power.

In contrast with our Middle Atlantic and East North Central states, which have easy access to great supplies of coal, our Pacific states are indeed coal-poor. Fortunately, they have the temporary advantage of cheap California oil and the enduring advantage of abundant water power. Of the remaining low-cost power sites capable of substantial future development, the largest are those of the Pacific Northwest, Niagara, and the St. Lawrence. In July 1954 ground was broken for the first phase of the $600 million joint Canádian-U.S. St. Lawrence Power Enterprise. The Columbia River system alone has about two fifths of the nation's hydro potential, and only a fraction of it has been harnessed to date.[6]

In recent years no section of the United States has equaled the Pacific Coast in water-power development and population growth. Between 1941 and 1951 the total capacity of water-power plants in California, Oregon, and Washington increased from 2.9 to 6.4 millions of kilowatts. Today these states possess one third of the nation's developed water power. In a single decade, 1940–50, their population increased from 10 to nearly 15 millions. British Columbia, their northern neighbor, is also booming—see indexes of current literature to get the picturesque, complicated, and amazing story of water power at Kitimat (Figs. 12, 15, and 36 top). During World War II many essential manufacturing industries were developed to use power provided by the gigantic Hoover Dam, Grand Coulee, and Bonneville projects, and the people of the West Coast hope for great future industrial development.

Other continents. In contrast with the great development of water power in Europe and North America, the water power of the

[6] The President's Materials Policy Commission, *op. cit.*, p. 119.

Water power wasting in the wilderness—Argentine-Brazilian boundary near Paraguayan line. Susquehanna type (Fig. 330) but worse, a rainy season and dry. ***Brazilian Embassy, Washington, D. C.***

other continents is little used. Two thirds of the developed horsepower of Asia are to be found in tiny, industrialized, mineral-poor Japan, and about three fifths of the developed power of South America is consumed by the infant industries of Brazil, especially around São Paulo and Rio de Janeiro. The colossal potential resources of Africa are virtually unused. It is unfortunate that so much of the world's potential water power lies so far away from population centers and markets. For a long time to come it is likely that the great bulk of the world's water power will continue to flow away to sea, unused by man.

4. OTHER SOURCES OF POWER

Wind power. Long before the dawn of recorded history, primitive man rigged his boat with a sail to use the motive power of the wind, and it was not until the 1890's that the number and tonnage of ocean-going sailing vessels was surpassed by steamers. In China the freight-carrying wheelbarrow, propelled by a sweating coolie with the aid of a sail, has long been a common sight. Crude wooden windmills are also of ancient origin. Windmills have long been used in the Netherlands and Asiatic countries for pumping water and in trade-wind lands for grinding sugar cane. The modern steel windmill pumps water on the windswept Argentine pampa and limestone plains of Yucatan. Until the advent of gasoline and electric pumps, the windmill was widely used on the level lands of our Corn Belt and Great Plains.

Alas, wind is fickle! Perhaps some day great fields of improved multivaned windmills, each with a dynamo, will be installed in such windy places as the top of the Alleghenies, the top of the White Mountains, the shores of the Great Lakes, Cape Cod, and elsewhere—all harnessed into one great system—so when the wind dies down in one or two places, it can be used in others. Inventors have been working on rotors and other devices for harnessing the wind, but as yet none has proved economical for large-scale use. At the present time wind power accounts for a negligible fraction of the world's daily output of work.

Tidal power. The cosmic force of gravitation and planetary momentum gives us the tides. These we have used but little, although methods for their utilization have been per-

fected. The British have already impounded several square miles of high tide, 20 feet high, in the estuary of the Severn, south of Wales. As these high tides are three hours apart, and as the water is made to work as it goes into tidal basins and out of them, the prospect of almost continuous power is an important aspect of the enterprise. An experimental plant on the Bay of Biscay in France has been utilizing tidal power successfully for some time.

In the 1930's it was proposed to harness the tide at Passamaquoddy Bay in Maine at the southern end of the Bay of Fundy, where a great tidal range and a favorable shoreline afford unusual power possibilities. This New Deal project was killed by Congress. Some day the fiords of Norway and the lochs of Scotland may attract the attention of power engineers. Ocean tides, like waterfalls, must be utilized *in situ*. Tides can supply only a minor part of the world's power needs.

Heat from the earth and sea. Another cosmic power source of considerable promise is earth heat, especially around the areas of volcanic energy, active or latent, as evidenced by hot springs. This source of heat is being used to run steam engines and electric generators and to do industrial service, in Tuscany, Italy, and in California.

For an island that is tangent to the Arctic Circle, little Iceland does very well. Its Lake Thingvalla is fed by hot springs and never freezes, making an ideal landing place for seaplanes. Water is carried in pipes from the hot springs 10 miles to Reykjavik, the capital city, where it is used to heat 3000 homes, all public buildings, and hospitals.[7] The hot water is also used in the public laundries. With the aid of the heat from the earth's hot water, bananas, citrus fruit, vegetables, and flowers are now being grown in hothouses. Icelanders have long been a progressive people.

An ingenious device is the electric heat pump, which takes heat from the constant temperature of soil or water below the frost line and discharges it into a house. Heat pumps have been used experimentally with success, as the following account indicates:

> In terms of fuel consumption the heat pump is efficient. One therm of coal in a furnace will produce about three-quarters of a therm of room heat. But when the same unit of coal is converted to electricity to operate a heat pump, it can produce one and a half therms of heat. The additional energy is the contribution of the sun, which maintains this constant soil or water temperature.
>
> But since the difference between freezing or zero weather and the 54-degree earth temperature is considerably less than the differential provided by a fire, a greater quantity of earth's lower heat must be used. An area of at least 100 feet by 30 feet for underground piping, or a large supply of deep well water would be needed to heat even a small house. Hence, the application of the heat pump in cities is limited. And for the present, the cost of equipment and of installation is high, although tests run by the U. S. Department of Agriculture in five Kansas farm houses, during the winter of 1950–51, showed the heat pump systems equal to conventional systems in over-all economy.[8]

We can boil ether and probably other cheap chemicals by subjecting them to the heat of ocean water at a temperature of 80°. We can condense them by subjecting it to cold water at a temperature of 40°. It so happens that there are millions of square miles of tropical ocean surface with the above high temperature, while a half mile below are limitless cubic miles of water with the requisite low temperature—the one fed by tropic sunshine and the other by Arctic chill whose cold waters fill all deep seas and are continuously replenished by both polar zones. This offers interesting power possibilities to the engineer who observes that many West Indian islands have both kinds of water within a mile of the surf. Experiments have been made by Georges Claude along the coast of Cuba.

Solar energy. All other sources of power pale beside the great source—the direct rays of the sun which are calculated to hurl into 9000 square miles of Egypt enough power to

[7] "Iceland Heats Capital with 'White Coal,'" *The Christian Science Monitor*, August 13, 1951, p. 7.

[8] Bituminous Coal Institute, *1951 Bituminous Coal Annual*, Washington, 1951, p. 179.

replace all the engines and water wheels in the world. By means of mirrors and other devices, solar energy has been harnessed on a small scale. The success of such power development to the point of superiority to existing power sources offers interesting speculation as to where would be natural seats of empire when the best sources of power were within the zone of 200- or 400-mile power transmission from hot and nearly cloudless deserts. If solar engines are ever perfected, deserts may become some of the world's most valuable real estate.

Atomic energy. The newest and the most spectacular source of power is atomic energy obtained from fissionable materials that are capable of maintaining a chain reaction. Uranium and plutonium, which can be derived from uranium, are the chief fissionable materials at present, although thorium and perhaps other materials can be used. A single pound of uranium or plutonium can produce 12 million kilowatt-hours of electric energy, or more than is usually obtained from 6000 tons of coal.

The largest known producers of uranium are Canada, the Belgian Congo, Czechoslovakia, the United States, Australia, and South Africa. Thorium is produced in India and Brazil. Graphite and beryllium are needed for fission control in nuclear-energy machines. Nearly one half the world's graphite is mined in Mexico, Japan, and Madagascar, while Argentina and Brazil are major producers of beryllium.

Atomic bombs dropped upon Hiroshima and Nagasaki in 1945 marked the dawn of the Atomic Age, and since then atomic energy has been used almost entirely for military purposes. An atomic submarine has been built, atomic airplanes are planned, and there seems to be little doubt that ships and locomotives can be driven with atomic power. In November 1951, at Harwell, England, 80 offices at a research center were equipped with central hot-water heating, piped in from the nearby experimental atomic pile.

The potential economic uses of atomic energy are apparently legion.[9] Ultimately atomic energy may be used in many industries. It is conceivable that fissionable materials could be distributed throughout the world and bring about the development of manufacturing in many countries that are lacking in mineral fuels.

[9] See Sam. H. Schurr and Jacob Marschak, *Economic Aspects of Atomic Power,* Princeton University Press, Princeton, 1950.

August 17, 1955. Announcements (N. Y. Times, *Aug. 15–16*) *from international conference on atomic energy at Geneva.*

1. Heavy hydrogen in sea water. We may soon set up our churns beside the sea and churn out the miniscule fractions of heavy hydrogen. Today a pound of it costs $200 and has the energy of $15,000 worth of coal at $10 a ton.

2. Harrison Brown, California Institute of Technology, reported that uranium and thorium occur in common granite and can be extracted "extremely easily." ". . . the energy costs required to process a ton of granite, leaching out its uranium and thorium, would be within the cost range of 25 to 48 lbs. of coal." At present only about 25% of the uranium and thorium is leachable—thus a ton of granite becomes "the energy equivalent to 10–15 tons of coal."

Three problems remain:

a. How to harness the fierce heat.
b. How to prevent damage by radiant "ash."
c. To make man behave himself for the next few hundred thousand years while we have power unlimited by this superindustrial revolution.

Truly we have eaten the fruit of the tree of knowledge. *Gen. Chap. 3.*

20· Iron and Steel—The Backbone of Modern Industry

1. THE AGE OF IRON AND STEEL

Basic resource of the modern Machine Age. "Nothing in American industry is made without steel." Ponder that amazing sentence, and you will wish for a stronger word than *basic* to describe this resource. We really need a new word. We are a bit like the countryman who said, "We need some new laws, must have some new laws—old ones done all been broke."

Iron in the form of steel is so important because of its hardness, strength, and durability, because of the ease with which it can be cast and worked into any desired shape, and because of its remarkable cheapness under modern methods of production.

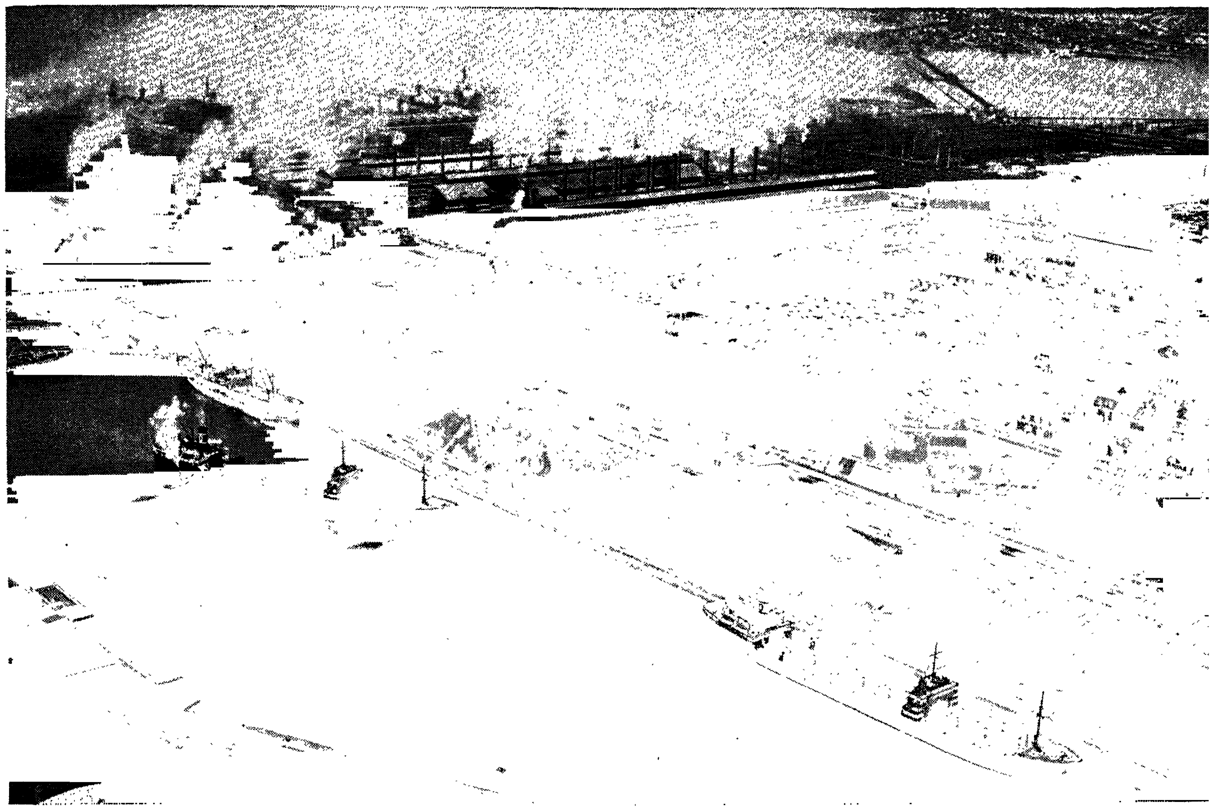
Chiefly from iron and steel are made the engines and mechanisms that harness the tremendous power derived from the mineral fuels and falling water. From iron and steel we create a multitude of machines that have so increased the effectiveness of human labor—machines that transform raw materials into myriads of products wanted by mankind; machines that convey men, goods, ideas, and power; machines that plow and sow and reap; machines that drill, dig, construct, control, calculate, write, and almost think; and machines that are used to produce more machines.

Without the power-driven machine, the work of the world would again depend primarily upon the muscle of man and beast, and millions of men would promptly starve.

The energy that keeps modern industry in motion is derived chiefly from coal, but the sturdy backbone that supports all industrial development is made of iron and steel. Only those nations that possess or have easy access to large supplies of coal and iron and steel have achieved outstanding industrial progress, great wealth, and political power in modern times. These nations, too, are the leading military powers, for steel is the greatest of all sinews of war. Verily, coal and iron are the twin pillars of physical strength underlying our industrial civilization of today.

Chief uses. Steel is merely iron that has been hardened and given desirable qualities by the addition of carbon and other alloys. Its prime function today is to serve as a raw material in the production of durable goods that will withstand great stress and strain and also the shock, wear, and tear of repeated use. From this strong and durable material are made the heavy machinery and equipment needed in vast quantity and variety by modern industrial society.

By alloying iron with small amounts of other metals, steel can now be made hard or soft, tough or brittle, pliable or rigid to serve varied needs. Probably 90% of the world's



Sparrows Point steel works, Baltimore harbor: ocean freighters in dock, traveling crane, ore storage, blast furnaces (by cylinders), long steel mills with smoke. ***Bethlehem Steel Co.***

iron is now converted into steel. Furthermore, it should be noted that iron has unusual magnetic qualities which make it indispensable to the electrical industry, where it is used in the manufacture of dynamos, motors, telephones, telegraph instruments, radios, and other electrical equipment.

In the United States, where long distances require huge transport facilities, over one fourth of our entire steel output in times of peace is used for transportation purposes (see Table 20:1). More than one sixth of our steel is needed by the construction industry, whereas only a small portion is devoted to the production of nondurable consumers' goods, such as tin cans and other metal containers that are used but once.[1] So great has been the growth

TABLE 20:1. Percentage Distribution of Steel among Consuming Industries in the United States

	1941–44 average	1951	1953
Automotive and aircraft	8.9	18.8	20.8
Machinery and tools	5.1	8.8	9.1
Oil, gas, water, and mining	3.5	8.1	9.0
Construction and maintenance	13.3	18.1	17.8
Containers	6.7	9.3	8.5
Railroads	8.6	8.6	6.8
Pressing, forming, and stamping	4.5	6.1	6.2
Exports	12.2	3.6	3.7
Agriculture	2.5	4.2	3.2
Shipbuilding	15.3	1.2	1.2
All others	19.4	13.2	13.7
Total	100.0	100.0	100.0

Source: "Steel Distribution by Consuming Industries," *The Iron Age,* January 3, 1952, and April 8, 1954.

[1] See Douglas A. Fisher, *Steel in the War,* United States Steel Corp., New York, 1946. On August 13, 1952, *The New York Times* reported that 15% of the American steel output was being used for defense purposes.

of the American steel industry that today the total weight of steel in use in this country amounts to more than 14,500 pounds per capita as compared with the use of ½ pound of wrought iron per capita at the time George Washington was inaugurated as our first President.[2] Throughout the United States more than 1 billion tons of steel are now in use.

2. THE FORMATION, DISTRIBUTION, AND MINING OF IRON ORE

Formation of iron ore. Iron exists practically everywhere throughout the earth's crust. Iron ores are plentiful, but the metal is never found even in a reasonably pure state except in recently fallen meteorites. It is dissolved from almost every hillside by the leaching rainwaters, and where a stream of water with iron in solution enters a stream of water with lime in solution, iron ore is deposited. For this reason we have a string of iron deposits in the United States from northern Vermont to central Alabama.

Sometimes iron streams flow into small lakes, where lime or certain organisms cause the deposit of the ore in nuggets upon the bottom, the so-called bog ore which has at times been quite an important source of the world's iron industry. Bog ore was formerly collected at intervals as a kind of harvest on lake bottoms in Sweden, but dredging operations were discontinued a few years ago, as the yield was too small.

The principal iron ores in use today are *hematite,* a red or gray iron oxide that is by far the leading source of iron; *magnetite,* a black, magnetic iron oxide; *limonite,* a brown, hydrous iron oxide; and *siderite,* or iron carbonate. Hematite, limonite, and siderite are sedimentary or residual ores; either they were deposited as sediments or they were residual deposits of iron that were left when other materials had eroded or washed away. Magnetite is a primary ore that was formed with igneous rock.

Where the conditions suitable for the deposit of iron ore continue undisturbed for great periods of time, we have large deposits, veritable mountains of ore, such as exist in the rough country around the western tip of Lake Superior, at Magnitnaya (Magnetic Mountain) on the eastern slopes of the Urals, at Itabira in the highlands of eastern Brazil, near Santiago de Cuba in the Sierra Maestra of southeastern Cuba, and at Cerro Bolivar on the northern edge of the Guiana highlands of Venezuela.

Economic availability of iron deposits. Whether or not it is profitable to exploit a given iron deposit depends largely upon its richness, purity, depth, size, and general location. Very little iron ore is mined today that contains less than 30% of iron.[3] In the United States, which is fortunate in having large and rich deposits, nearly all the ore that is mined has an iron content of more than 50%. The world's richest deposits, with an iron content exceeding 65%, are those of the Iron Knob district in southern Australia, the Krivoï Rog district of southern European Russia, at Itabira in eastern Brazil, at Kiruna in northern Sweden, and at El Tofo near Coquimbo, Chile. The newly discovered deposits at Cerro Bolivar, Venezuela, and Ungava, Labrador, contain about 60% of metallic iron.

All iron ores contain some impurities, such as oxygen, silica, alumina, magnesium, sulfur, arsenic, titanium, and phosphorus. Some of these, especially sulfur, titanium, and phosphorus, are objectionable, since they tend to weaken iron, and for a long time they were difficult or expensive to remove in iron and steel making. Indeed, it was not until 1878 that new processes made phosphoric iron ores available for use.

[2] United States Steel Corp., *A Pictorial Presentation of a Basic Industry,* New York, 1939, p. 3, and Douglas A. Fisher, *Steel Making in America,* United States Steel Corp., New York, 1949, p. 11.

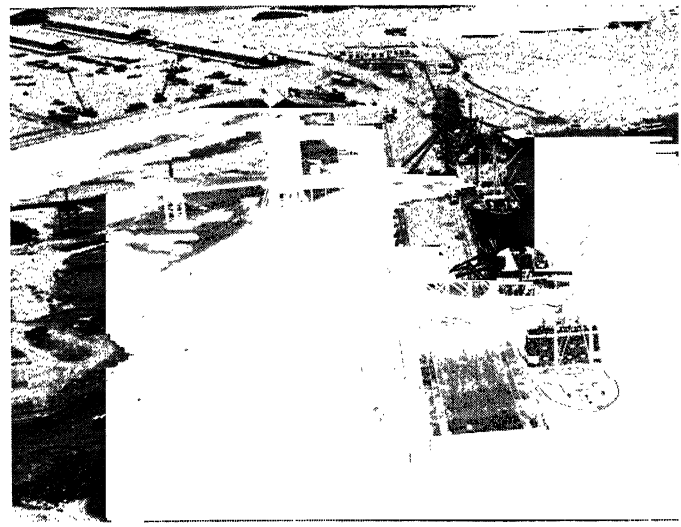
[3] The maximum percentage of metallic iron found in magnetite is 72.4%; in hematite, 70.0%; in limonite, 59.9%; and in siderite, 48.3%.

The desirability of an iron ore deposit is also affected by its geological formation and depth. Open-pit operations are obviously much cheaper than shaft mining, and many a deposit of lesser richness and purity is used because it lies near the surface. Over half of the world's iron ore is now mined with open-pit methods.

While the relatively small demand for iron a century and half ago could be easily supplied from a large number of small and scattered deposits, the great demand for steel in recent times has led to the concentration of mining operations on those deposits with large reserves adequate to support large-scale production for a long period of time. Hence, many a small deposit of superior richness and purity has been abandoned.

Finally, it should be noted that since iron ore is so heavy and bulky in proportion to its value, it cannot be moved very far in large quantities unless cheap transportation is available. Since modern methods of iron and steel manufacture can utilize iron ores that vary greatly in richness and purity, those large deposits that are located near the market or near cheap water transportation are utilized most intensively. The great bulk of all iron ore is manufactured into steel in the midst of the highly industrialized areas that have arisen in and near the world's great coal fields. Here are the largest markets for finished steel products, and here are the coal and coke that are indispensable for steel making.

Distribution of iron mining. Although iron is more widely distributed throughout the earth's crust than any metal except aluminum, and although some 45 countries are engaged in mining iron ore, we find that more than 85% of the world's iron ore is mined each year in the United States, the Soviet Union,



U. S. Steel Corp. ocean freighters, Cerro Bolivar ore—Puerto Ordaz, Venezuela. Three belt conveyors and gravity move ore at left margin of picture to ship's hold. Shipping 5 million ton year rate; expect 10 million soon. ***U. S. Steel Corp.***

France, Sweden, Great Britain, Germany, and Belgium-Luxembourg.[4] All these countries except Sweden have important coal deposits and great industrial markets. Sweden, having no coal, must export about 90% of her iron ore. The other six countries manufacture more than 80% of the world's steel (see Fig. 365 and Tables 17:4, 20:2, and 21:4).

In contrast with the scattered pick-and-shovel production of iron ore little more than a century ago, the mining of iron ore today is a large-scale, power-shovel-and-big-machinery business. The steel company of today operates iron mines, coal mines, limestone quarries, steamship lines, coke ovens, blast furnaces, steel furnaces, rolling mills, forge shops, foundries, and various fabricating shops.[5] With an eye to the future supply of iron, some of these huge American and European con-

[4] Since 1922 Luxembourg and Belgium have been linked together in a customs union with no tariff barriers between them.

[5] In the United States 18 fully integrated companies control 90% of the nation's steel-making capacity. Evan B. Alderfer and Herman E. Michl, *Economics of American Industry,* McGraw-Hill Book Co., New York, 1950, p. 30. Also see Ervin Hexner, *The International Steel Cartel,* The University of North Carolina Press, Chapel Hill, N. C., 1943, and Douglas A. Fisher, *Steel Serves the Nation, 1901–1951, The Fifty Year Story of United States Steel,* United States Steel Corp., New York, 1951.

TABLE 20:2. Estimated Iron Content of the World's Iron Ore Reserves

Country	Total probable reserves	Total potential reserves	Probable reserves per capita	Potential reserves per capita
	Billions of metric tons		Metric tons	
India	5.6	10.3	16	30
Brazil	4.1	10.8	85	223
France	2.5	3.9	61	93
U. S. S. R.	2.0	4.3	11	23
United States	1.7	25.5	12	174
Sweden	1.4	1.6	205	233
Union of South Africa	1.3	5.1	107	428
Cuba	1.2	5.4	233	1,047
Southern Rhodesia	1.1	50.7	577	25,591
French West Africa	1.0	1.0	63	63
Canada	.9	2.2	70	168
China	.8	1.2	2	3
United Kingdom	.7	.9	13	18
Philippines	.5	.5	24	24
Spain	.4	.6	13	23
All others	1.5	4.8	—	—
World total	26.7	128.8	11	55

Note: Probable reserves are those which have been calculated upon the basis of actual geological investigation. Potential reserves include probable reserves and also other deposits that have been estimated approximately.
Source: Adapted from U. N., Department of Economic Affairs, *World Iron Resources and Their Utilization,* Lake Success, N. Y., 1950, pp. 66–67.

cerns have made large investments in iron ore reserves overseas.[6]

All the leading industrial nations, with the exception of the Soviet Union and France, are dependent upon imports of iron ore. The significant feature of the highly industrialized nations is not the size of their domestic iron ore reserves but the intensity with which available ores are used. In terms of metallic content, the probable iron-ore reserves of India and Brazil are the largest in the world, (see Table 20:2). India, however, mines less than $1\frac{1}{2}\%$ of the world's iron ore and produces less than $1\frac{1}{2}\%$ of the pig iron, while Brazil ranks even lower. Other industrially underdeveloped countries also rank high in reserves and low in use. Such nations are now being called upon to help supply the world's increasing demand for iron ore.[7]

3. THE DEVELOPMENT OF IRON MANUFACTURE

Modern steel making usually has three major steps in production: (1) the reduction of iron

[6] Estimated total iron ore imports into U. S., 1954, 16,000,000 as against 12,000,000 in 1953 and probably near 20 million in 1955.

Estimated 12-month 1954 receipts from:

Venezuela	5,000,000
Canada	3,000,000

Figures for Jan.-Sept. receipts	1954	1953
	thousand tons	
Peru	1,785	423
Chile	1,428	1,976
Sweden	1,383	1,833
Liberia	618	567
Brazil	540	567
B.W. Africa	214	226

Source: The New York Times, Sec. 3, Jan. 2, 1955, p. 1

Shipments from Quebec-Labrador to U. S. began mid-1954 and are expected to be 6,000,000 in 1955.

[7] See U. N., Department of Economic Affairs, *World Iron Ore Resources and Their Utilization,* Lake Success, N. Y., 1950, and American Geographical Society, "Outlook for Steel," *Focus,* April 15, 1951.

ore to pig iron in a blast furnace, (2) the further purification of iron by converting it to steel in steel furnaces of various types, and (3) the shaping of the metal by rolling, forging, pressing, or casting.[8] These three stages —ore reduction, purification, and shaping of metal—have characterized iron (and steel) manufacture since the earliest days, although the techniques and equipment of the ancients would hardly be recognized by steel makers of today.

The early use of iron. Iron was first used by man long before the dawn of history, its use generally following that of copper and bronze. Not only tools and weapons wrought of iron, but also remains of crude furnaces have been found on sites of ancient civilizations in many parts of the Old World. Iron is extracted from ore by burning off the impurities, the chief of which is oxygen. No ordinary fire will make sufficient heat. But early man learned that a primitive bellows, powered by hand or foot, could force air through a crude forge and make it hot enough to reduce the iron to a sticky mass in the bottom of the fire. This was purified by reheating and hammering to make wrought iron of exceptional quality. Like the early hand looms, simple forges were pretty much alike the world over and now are commonly called Catalan forges, after the Spanish province of Catalonia.

The blast furnace. Toward the end of the medieval period, the stacks of the Catalan forges were made taller, and the air draught was made stronger until finally the blast furnace was developed in Belgium about 1340. The higher temperatures in the blast furnace melted the iron into liquid form, which absorbed impurities and was of poorer quality than the more expensive product of the old forges. However, this liquid iron could be run off into molds (later called "pigs"—hence pig iron) for cooling in convenient form. The blast furnace, like many inventions, sacrificed quality for quantity and cheapness. Later improvements made it much more economical than the Catalan forge in the use of fuel, ore, and labor.

Charcoal was the universal fuel for the early blast furnaces as it had been for the Catalan forge. This limited the size of the blast furnace, because it was impossible to pile up a charge of ore and charcoal very high, as the weight of the ore would crush the soft charcoal and smother the fire. Also, even the small furnace consumed so much charcoal over a period of years that forests in its vicinity became denuded and charcoal had to be transported from increasing distances or the furnace abandoned. The geography of the iron industry was therefore one of small furnaces in scattered and often temporary locations in forested areas where local ores were available.[9]

Coke and other improvements. The use of coal for fuel freed the industry from the limitations of the charcoal furnace and paved the way for development of the modern industry.[10] In 1709 the Englishman Abraham Darby first used coke in smelting, and 60 years later it was in general use.

Freed from the tyranny of charcoal and water power, the iron industry moved to the coal fields, for in the mid-eighteenth century 8 to 10 tons of coal were needed to reduce 2 or 3 tons of ore to a single ton of pig iron. Improvements in the blast furnace, however, steadily decreased the amount of coal required for smelting. For example, in the 1820's the

---

[8] See The President's Materials Policy Commission, *Resources for Freedom,* Washington, Vol. 4, 1952, pp. 31–40.

[9] In Elizabethan England the iron industry came into disrepute and was subjected to restrictive legislation because, to keep itself going, it followed the vanishing forests of England from place to place. By the early eighteenth century English iron output had declined and imports had increased from Germany, Sweden, the Ural District in Russia, and the American Colonies.

[10] To make coke, coal is "burned" (heated) in closed space that prevents much combustion. Impurities are driven off (largely as gas), leaving coke, almost pure carbon which is harder and more porous than coal. Therefore, coke does not crush under the heavy loads in a blast furnace and burns with a cleaner, hotter flame.

introduction of the hot (preheated air) blast in a Scottish iron works reduced its coal requirement from 8 to less than 3 tons per ton of pig iron.[11]

Another factor that drew the iron industry to the coal fields was the coal requirements of the process of purifying and shaping pig iron. Here again, innovations improved the quality of the product and soon reduced the amount of coal required. In 1784 Henry Cort perfected the puddling furnace, heated by coal, which removed most of the carbon from the pig iron, thereby making it malleable. The product, puddled wrought iron, was processed in rolling mills and shaped for many uses.

The Iron Age. By 1860 world production of iron had risen to 7.4 million tons, in contrast to the ½ million tons of 1800, and the major changes that this cheap metal brought to manufacturing, transportation, agriculture, and war were well under way. England, its iron industry revitalized, produced over half the world total, for no other nation of the early nineteenth century had economic access to such resources of fuel, ore, and technology. This was still the "iron age," and steel production was only one twentieth that of iron in 1860. But the stage was set for technological innovations in steel production that were to revolutionize the industry, make possible its great increase in production, and greatly alter its location in the years to come.

4. THE DEVELOPMENT OF MODERN STEEL TECHNOLOGY

Early developments. The process of refining iron into steel, with its generally superior qualities, long proved both difficult and expensive. The Romans, with their well-developed iron industry, found that carbon added to iron increased its hardness and produced steel. Various early methods culminated in the crucible process, in which wrought iron was melted in a clay or graphite pot and carbon or other alloys added directly to the molten iron to produce steel of higher and more uniform quality. Important development of crucible-steel production at Sheffield, England, during the eighteenth century formed the basis for that center's wide and continuing renown as a producer of high-grade steel and its manufactures.

The Bessemer process. Despite these achievements, steel remained expensive, and the world waited for a low-cost method that could take advantage of the eighteenth- and early nineteenth-century improvements in iron production. This was achieved by the process invented independently by William Kelly of Kentucky in 1847 and Henry Bessemer of Great Britain in 1855 and known as the Bessemer process.

In this process molten pig iron is poured into a pear-shaped, tilting converter and a strong blast of air (usually cold) is forced upward through the molten mass. Violent combustion ensues, and the oxygen of the air blast burns out the carbon, silicon, and manganese. Then ferro-manganese is added to the molten mass to restore the necessary amounts of these elements. The process required no additional fuel and could produce large tonnages since a Bessemer furnace can convert 20 to 25 tons of pig iron to steel in about 10 minutes.

Steel from the cheap and speedy Bessemer process was suitable for many uses and soon liberated railroads from the use of costly wrought iron rails and greatly stimulated other uses of steel. Its saving in fuel further freed the industry from such complete dependence on coal-field locations. However, Bessemer steel cannot stand great stress and strain and would sometimes break without warning under the increasingly heavy use to which the transportation and other industries subjected steel products. Hence, it is now used chiefly in the manufacture of pipe, wire, and wire products, and we turn to the second major advance in steel technology which was developing at this same time.

The open-hearth process. In 1856 William Siemens, an English inventor of German

[11] See Walter Isard, "Some Locational Factors in the Iron and Steel Industry since the Early Nineteenth Century," *Journal of Political Economy,* June 1948, pp. 203–217.

birth, patented the open-hearth process that has become the world's chief method of making steel. The rectangular furnace contains a shallow basin, or open-hearth, in which the iron is heated by gas or oil flames passing over it (see Fig. 348). The furnace cannot be tipped like a Bessemer converter. Instead the slag containing the impurities floats to the top of the molten mass as cream floats on milk, and is drawn off through a spout at one side of the furnace into a ladle. The molten steel is similarly drawn off through a lower spout.

Since Siemens' day the capacity of open-hearth furnaces has increased from 5 to a maximum of 550 tons, the average furnace in this country holding about 150 tons. It requires from 8 to 15 hours to produce this amount of steel in an open-hearth. The process is therefore slower but much less violent than the Bessemer. Consequently, temperatures can be more carefully controlled, samples may be taken for analysis, and alloys or other materials added in exact amounts while the "heat" is in progress to produce uniform steel of various desired qualities. Although the cost per ton is generally higher than Bessemer steel, the open hearth can better meet the requirements of modern industry not only for strong, uniform, and reliable steel but also for a variety of steels for particular purposes. Open-hearth steel is actually low-cost steel when its superior qualities are considered.

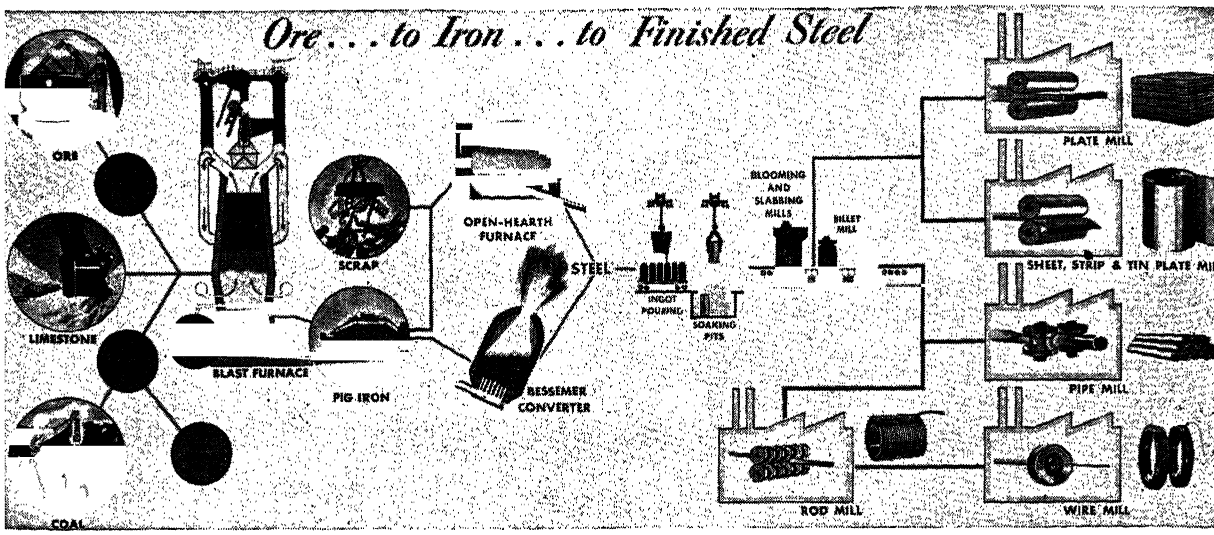
Another advantage of the open hearth is that much more scrap can be used as raw material.[12] Some open hearths operate on scrap exclusively if other materials are too costly or not available. Less fuel is needed to melt scrap than to produce pig iron. The use of scrap, and even iron ore, as part of the charge has helped to reduce the cost of ingot steel. About half the metal now melted in the world's iron and steel furnaces is scrap.

These two advantages—superior quality of product and more varied raw materials—have been the major reasons for the supremacy of open-hearth over Bessemer steel. Open-hearth steel got off to a slow start. In the United States it was not until 1907 that the two processes were of equal importance, but now approximately 90% of our total output is open-hearth steel. On a world basis, the proportion is slightly lower. However, the Bessemer process remains indispensable in France, Belgium-Luxembourg, and a few other areas which depend heavily upon phosphoric ores. This brings us to a third major development in steel technology.

Steel pouring into ladle from open hearth. Lighter slag on top runs into slag thimble. Ladle, many tons, swings away to billet molds. ***Bituminous Coal Institute***

"Basic" steel. Iron and steel furnaces must be lined with fire brick to prevent the furnace itself from melting. At the time of the first Bessemer and open-hearth furnaces, fire brick was made from sandstone whose silica gave it an acid chemical reaction. It was soon found

[12] A Frenchman named Martin discovered this technique, and the open-hearth is often called the Siemens-Martin furnace, another example of the way inventions remake our world.

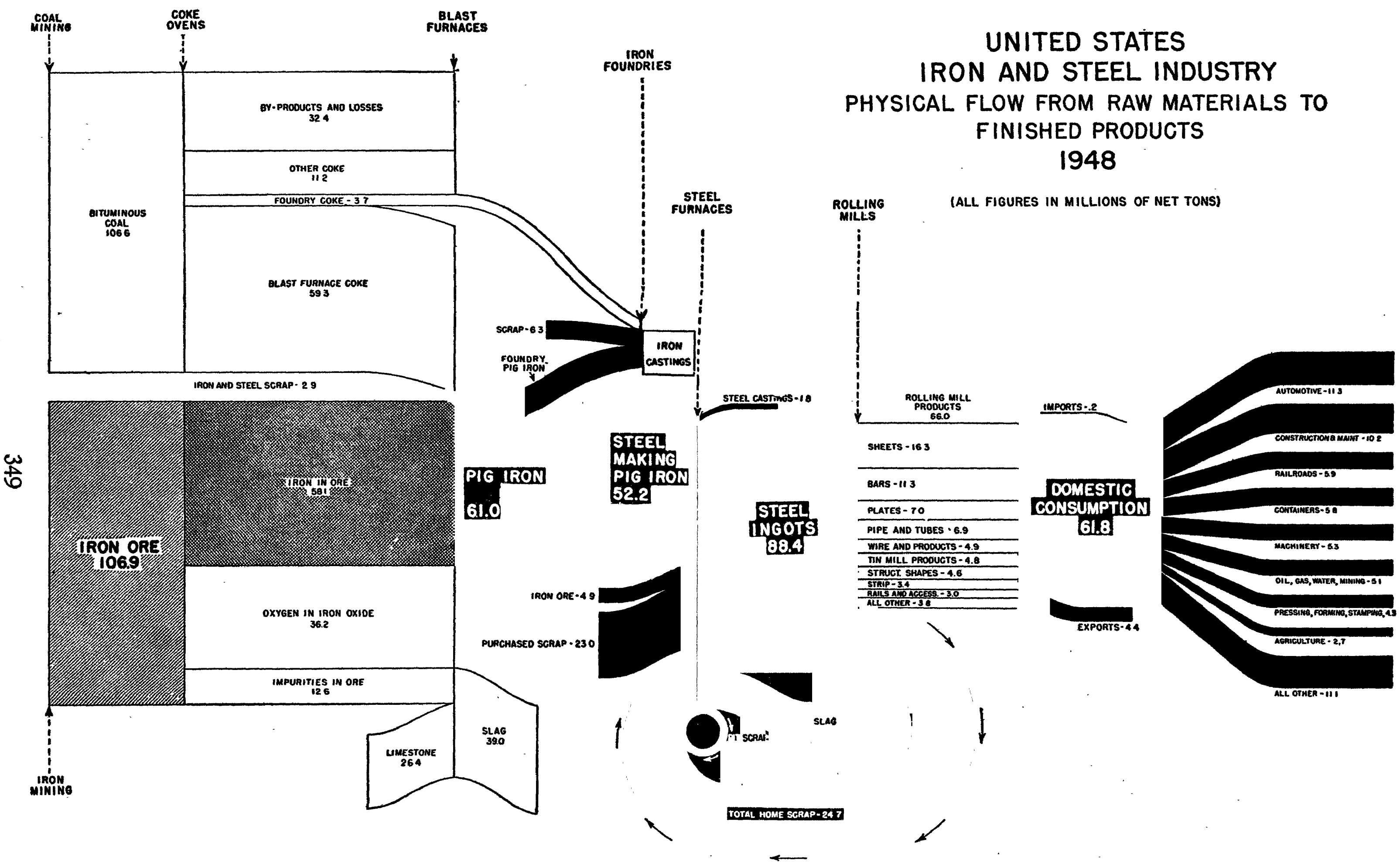


Flow line: journey of iron that does not get cold until in a few hours it has become finished steel. The ladle, filled at open hearth, pours into ingot molds on a car. Soaking pit, flame, keep ingots hot. Blooming, slabbing, and billet mills do first shaping and pass pieces on to finishing mills—plate, rails, structural, sheet, etc. These may be several times as long as a football field. Steel plant size requires a dozen Corn Belt farms. *Bethlehem Steel Co.*

that Bessemer converters with this "acid" lining could not remove the phosphorus from iron containing more than 0.1% of this acid element, and a brittle, useless steel was the result. This restricted the Bessemer process to pig made from virtually phosphorus-free ore which was (and is) limited in amount. Fortunately, in 1878 Sidney Thomas and Percy Gilchrist, amateur chemists living in England, suggested that the phosphorus could be removed by merely substituting limestone, which has a basic reaction, for the acid lining of the Bessemer converter. This proved to be the case, provided the iron had a phosphorus content of 2% or more. High-phosphoric ores could therefore be used for steel production, and "Thomas" slag became an important fertilizer material because of its phosphorus content.

The basic lining was also applied to the open-hearth, with the first such furnace built in England in 1884. These furnaces handled iron from medium-phosphoric ores, with a maximum of nearly 2% phosphorus content. This innovation greatly increased the ore resources of the world by making a wider range of ores available for the quantity production of low-cost steel. High-phosphoric ores like those of Lorraine and of Birmingham, Ala., had been virtually useless for this purpose, and the rapid development of Lake Superior ores was made easier. From this it is clear that the basic process also allowed the iron and steel industry to develop in new locations.

The electric process. In the late years of the nineteenth century electric furnaces were used for the commercial production of steel in Italy, Sweden, and France, where hydroelectric power was cheap and mineral fuels less available. The modern electric furnace is a steel shell, lined with basic or acid refractory bricks, with the heat delivered by electrodes that extend down from the roof. Its raw material may be cold or molten pig iron, scrap iron or steel, or either Bessemer or open-hearth steel for further refinement. The electric furnace achieves higher temperatures and better control of heat than other processes and its primary function, therefore, is the production of super-quality steel involving the use of especially high-grade alloys. In the United States only about 6% of our steel production is from electric furnaces, but



Study this a bit, and it will mostly explain itself—how 240 tons of material become 61 tons of pig; how ingot doubles back on itself as scrap; how rolling mills split it up, and how industries split it again. *Adapted from U. S. Department of Commerce chart*

TABLE 20:3. Principal Nonferrous Metals Used by the Steel Industry

Metal	Reason for use	Typical applications	PREWAR AVERAGE			WARTIME AVERAGE		
			% of world production produced in U.S.	% of world production consumed in U.S.	Chief sources of U.S. supply	% of world production produced in U.S.	% of world production consumed in U.S.	Chief sources of U.S. supply
Aluminum	Removes gases and impurities; aids surface hardness	Seldom more than a trace remains, except in nitrided steel	30	40	U. S.	35	35	U. S.
Chromium	Small amounts improve hardening qualities; more than 10% prevents rust	Tools; machinery parts; stainless and heat- and acid-resisting steels	Insignificant	35	Africa, Cuba, Greece, New Caledonia, Oceania	5	50	Africa, Cuba, Greece, New Caledonia, Oceania
Cobalt	Holds cutting edge at high temperatures. Improves electrical qualities	High-speed cutting tools; permanent magnet steel	None	10	Canada, Belgian Africa, Australia	Insignificant	50	Canada, Belgian Africa, Fr. Morocco
Copper	Retards rust	Roofing and siding sheets, plates	40	35	U. S.	40	60	U. S., Chile
Lead	When mixed with tin, forms a rust-resisting coating for steel. Small amounts alloyed with steel improve machinability	Sheet steel for roofing, auto gasoline tanks, etc.; machinery parts	30	35	U. S.	27	50	U. S., Mexico, Australia, Canada, Peru
Manganese	Small amounts remove gases from steel; 1 to 2% increases strength and toughness; 12% imparts great toughness and resistance to abrasion	Small amounts present in all steels; 1 to 2% used in rails; 12% or more for frogs and switches and dredge bucket teeth	Insignificant	20	U. S. S. R., Gold Coast, Brazil, India	5	30	Gold Coast, Brazil, India, Cuba
Molybdenum	Increases strength, ductility, and resistance to shock	Tools; machinery parts; tubing for airplane fuselage	80	40	U. S.	90	75	U. S.
Nickel	Increases toughness, stiffness, strength, and ductility. In large amounts resists heat and acids	Tools; machinery parts; stainless steels; heat- and acid-resisting steels	Insignificant	50	Canada, Norway, New Caledonia	Insignificant	75	Canada, Cuba, New Caledonia
Tin	Forms corrosion-resisting coating on steel	Sanitary cans; kitchenware	Insignificant	45	British Malaya, United Kingdom, Netherlands India	Insignificant	45	Bolivia, Belgian Congo
Tungsten	Retains hardness and toughness at high temperature	High-speed cutting tools; magnets	10	20	China, British Malaya, U. S.	25	40	U. S., Bolivia, China, Argentina, Brazil
Vanadium	Increases strength, ductility, and resiliency	Tools; springs; machinery parts	15	25	U. S., Peru, Rhodesia	50	75	U. S., Peru, South West Africa
Zinc	Forms corrosion-resisting coating on steel	Galvanized roofing and siding sheets; wire fence; pails, etc.	35	35	U. S.	40	50	U. S., Mexico, Canada, Peru, Australia

Source: American Iron and Steel Institute, *Steel Facts*, February 1947, p. 4.

they produce over one third of our alloy steels.[13] Both in this country and abroad electric steel has virtually displaced steel made by the high-cost crucible process.

Alloy steels. Steel in 1900 was simply hard, medium, or soft, depending on its carbon content; alloy steel was almost unknown. The military requirements of two world wars as well as those of peacetime industries have called for increasing quantities of special-purpose, "tailor-made" steels (see Table 20:3) that now account for about 8% of the American steel output. Thus, tungsten and cobalt, which retain their hardness and cutting qualities under the red heat of great friction, are used in making high-speed steel for metal-working machinery. Molybdenum and vanadium are strong, tough, and resistant to shock and vibration, and they are used in steel for automobile gears and axles. Nickel and chromium steels are hard and strong and well suited for manufacture of armor plate, heavy guns, and ball bearings. They also resist corrosion and enter into production of stainless steel used in the laundry, food, chemical, and transportation industries. Manganese, being tough and resistant to abrasion, goes into steel for heavy machinery and railway rails. With the use of alloys, mostly in small quantities, it is now possible to manufacture steel to serve almost any purpose and to make steel products that will last much longer than formerly (see Table 20:3).

Shaping steel products. The many types of steel are poured from the furnaces into ingot molds, allowed to cool enough to solidify, and then, after reheating, move on to the rolling mill to emerge in an almost infinite variety of sizes and shapes. Red hot ingots, sometimes weighing as much as 25 tons, are run back and forth between heavy steel rollers. Sometimes they receive their final shape in the steel mill to leave in the form of railway rails, beams of various types, ship plate, pipe, wire, etc. In other cases the steel is roughly shaped into semifinished products destined for further fabrication. About half of all steel is rolled into flat forms, such as plate, sheet, and strip, because flat steel, like a flat board, can be made into so many things. It is estimated that fully 80% of all steel products pass through the rolling process at some stage of their manufacture (see Figs. 348 and 349).

Forging, another method of shaping steel, is accomplished by hydraulic presses and heavy, power-driven hammers, which give added strength and specific shapes to such steel products as railway wheels and axles. Casting of steel in specially prepared molds of the desired shape is used in making unusually large or complicated objects, such as frames of locomotives and turbines, large gears, engine blocks, and rudders, propellers, and stern frames for ships.

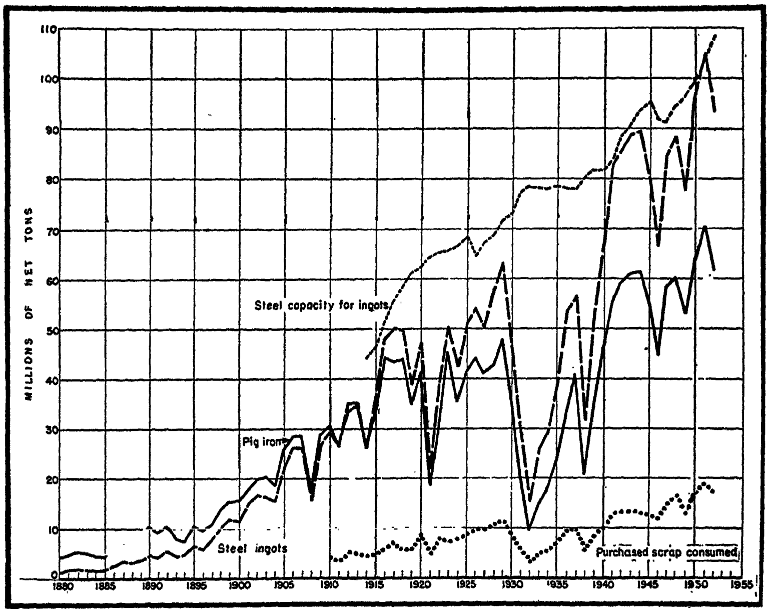
The Age of Steel. In reality the Steel Age is but a century old. The technological developments outlined above have made possible the increase in world steel production from less than ½ million tons in 1850 to more than 230 million metric tons in 1953. From a limited and expensive commodity, it has become one of the most versatile and cheapest available to man, selling in recent years for less than 5¢ a pound. To supply the growing demand a huge industry has developed, especially in favored localities.

5. SIZE, INTEGRATION, AND LOCATIONAL FACTORS

Plant size and integration in the steel industry. This increase in world steel production has brought into existence plants that are large in size and integrated in function—characteristics which are closely related and of prime importance to the economic geography of the industry.

Today's typical steel plant is big by any measure (see Fig. 341). Within limits, a large iron or steel furnace can produce at lower costs per ton than can a smaller one. The necessary raw materials and the finished product can be transported more economically in

[13] In fuel-poor Japan, on the other hand, electric furnaces account for over one fourth of the steel capacity, and their product is not restricted to high-quality steels.



The Age of Steel arrives. Steel, a fraction of iron output, passes it at World War I by the use of scrap. Industrial barometer: behold the 1930's. The Industrial Revolution was about 100 years old in 1880. Steel, the industrial barometer, shows how the revolution accelerates. *U. S. Bureau of Mines*

large amounts than in smaller tonnages. Rolling mills are large and also specialized, with different mills each producing a limited range of products and at lower unit-costs, providing that a market can be found for the output. Although these broad generalizations are subject to qualifications, it is true that the iron and steel industry is one in which low unit-costs may be achieved by large-scale operations.

Another explanation for the large plant size is that most plants are integrated, especially in the United States. The integrated plant contains coke ovens, blast furnaces, steel furnaces, and rolling mills at one location. This combination of functions leads to important savings in fuel and transport costs.

Fuel savings in the integrated plant result from the fact that the initial processes, especially the coke ovens, produce surplus "power" in the form of gas or heat. Some of this surplus can be used in the steel furnaces and rolling mills, if all processes are located together. In addition the metal does not have to cool completely as it moves through the integrated plant. Most pig iron is charged, still molten, into the steel furnaces, and the steel ingots generally move on to the rolling mills without cooling completely. This "hot-metal" processing would be impossible if the various processes were at different locations.

It costs less to move the large tonnages the short distances *within* the integrated plant than it would if the blast furnaces, steel furnaces, and rolling mills were miles apart. Also the steel processes, especially the rolling mills, "produce" much scrap as a by-product of their operations. This "home" scrap can be economically "transported" back to the steel furnaces of the integrated plant, where it makes up about one fourth of the metal used as raw material in the steel furnaces (see Figs. 348 and 349).

Changing locational factors. A large-scale, integrated iron and steel plant needs four things: (1) an abundant supply of iron ore of desirable quality; (2) a large supply of good heating and coking coal; (3) nearness to a densely populated, industrialized market with a large demand for iron and steel products and a sufficient supply of scrap metal; and (4) access to an adequate supply of capital and skilled labor, including men with executive and technical ability to organize and operate a large and complex industry. In terms of actual locational problems the first three

requirements are the most important,[14] because capital, labor, and managerial skill can be developed or imported if the other conditions favor the industry.

The major locational factors, therefore, are the transfer costs involved in access to coal, ore, and market, for these costs are the ones that vary most from place to place. The relative importance of these factors differs in various parts of the world, and also has changed greatly during the last century. In general, and since 1850, coal has lost its dominant position as a locational factor because of the continuing increase in fuel efficiency. This, as we have noted in the preceding sections, has been a major trend in the industry's technological development.[15] However, the amount of ore necessary to produce a ton of pig iron has not declined, partly owing to increasing use of ore with lower iron content. Consequently, in comparison to coal, ore has become *more* important as a locational factor.

But the importance of the market has increased relative to that of the other two. Steel products are bulky and expensive to transport.[16] With the increasing scale of production in the steel plant and the steel center, nearby markets must be found for huge tonnages of steel. In addition, the market's demand must be sufficiently diverse to absorb the various types of steel produced by a modern, integrated plant. In fact, the "market" has a double attraction for the steel plant—as a consuming area for its product and also as an important source of raw material. Industrialized areas in general and steel-consuming industries in particular are the major sources of the "purchased" scrap that is charged into the steel furnaces.

In the 1950's no single factor of the major three is dominant as a locational influence. The geographic coincidence of any two factors, however, is sufficient to determine the site of production. Of the three, it is coal and market that are most often found in the same area. This coincidence is owing to the historic relationships between steel-producing and steel-consuming industries and also to the fact that both have been drawn to regions of coal production, especially in the past. Consequently, the old English adage that ore moves to coal must be broadened by recognizing that, in so doing, ore generally moves toward the market. The lack of a local coal supply no longer precludes the development of steel production, but the limitations of the market remain as a major barrier to the large-scale steel industry in many parts of the world.[17]

The examination of these economic-geographic relationships as they exist at present and as they have developed is the major purpose of the following chapter.

[14] In the detailed selection of a plant site, questions of water supply, available power, existing transportation facilities, and level land areas assume great importance. But these are of greater significance in a local situation than in the evaluation of the potential of a larger area for the iron and steel industry.

[15] The amount of coal required to produce a ton of pig iron in Great Britain declined from about 5 tons in 1800 to 2.55 tons in 1873 and 1.67 tons in 1938—with 1.27 tons required in the United States in the latter year. Fuel economies have also characterized the development of the steel processes, although they are not so easily measured in terms of tonnage figures. See Isard, *loc. cit.*, from which much material in this final section has been taken.

[16] It has been estimated that transport costs per ton-mile for steel products are about three times those for either coal or iron ore. However, the higher value of products per ton makes it economically possible to ship them longer distances. Nonetheless, this is an indication of the "pull" of market locations for the industry. See Allan Rodgers, "Industrial Inertia, a Major Factor in the Location of the Steel Industry in the United States," *The Geographical Review*, April 1952, pp. 56–66, especially p. 58.

[17] For an analysis of the limitations of the market, even in a highly industrialized area, see Walter Isard and J. H. Cumberland, "New England as a Possible Location for an Integrated Iron and Steel Works," *Economic Geography*, October 1950, pp. 249–259.

21· The Distribution of Iron and Steel Manufacture

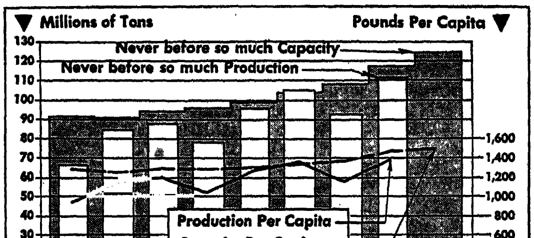
1. THE MAJOR STEEL REGIONS

The North Atlantic power belt. Iron and steel is *not* a frontier industry. It achieves its major importance in highly developed areas that can provide the necessary prerequisites of coal, ore, market, and technical development. Two such areas, facing each other across the narrow North Atlantic, continue to be the world's dominant iron and steel regions (see Chapters 2 and 16). On the west, the major iron and steel districts of the United States extend inland from the Middle Atlantic coast as far west as Chicago and St. Louis. This is the core region of the United States steel industry and, if other producing centers in this country and Canada be included, the North American continent accounts for about half of the world steel production (see Table 21:4).

On the eastern shore of the North Atlantic is western Europe where the countries from Spain and Italy, through western Germany, to Scandinavia contain nearly a third of the world steel capacity. In this area, political divisions and rivalries have complicated the international trade in raw materials and finished products which is necessary to support the major concentrations of the industry in Great Britain and across the English Channel in Germany, France, and the Low Countries.

The eastern extension of the North Atlantic power belt into the Soviet Union has emerged as virtually a separate iron and steel entity. Not only is it separated from western Europe by distance and a political-ideologic frontier, but also its iron and steel industry has developed in a different economic-geographic setting. The Soviet Union ranks second to the United States and produces more iron and steel than any West European country. However, even with the satellites in eastern Europe, the Soviet sphere ranks below the West European iron and steel region.

About 10% of the world steel is produced in centers outside of these three areas. The most important are found in Japan, China, India, Australia, South Africa, and several Latin American countries. These centers are



Astounding per-capita increase—one base of the Power Age, our rapidly increasing steel. ***American Iron and Steel Institute***

of major importance to the economies of their respective countries, and in some there is potential for further growth. Nevertheless, the producing centers within the steel regions of the North Atlantic power belt and its eastern extension in the Soviet Union will dominate the iron and steel world for the foreseeable future.

2. THE AMERICAN IRON AND STEEL INDUSTRY

Early developments. The early settlers needed iron, and the first successful iron works was built in 1644 on the Saugus River in Massachusetts, between Boston and Salem. The iron works consisted of a blast furnace and a forge, using charcoal, bog iron, and water power to produce about 7 tons a week. Both cast- and wrought-iron products were made and the iron works continued in operation for more than 100 years.[1]

The manufacture of iron expanded in colonial America; and by George Washington's time the little forges and blast furnaces, with a draught forced by a water wheel, were scattered from New England to Georgia and from the seacoast to Appalachian valleys in what now seem to be remote and isolated locations. Iron was made wherever the local blacksmiths needed iron, and a good ore bank, waterfall, and the vast American forest furnished the necessary raw materials. While England was at that time using coke, American coal lay far back in the forests of Pennsylvania and West Virginia, remote from all the paths of easy commerce. England's coal location close to harbors was most favorable.

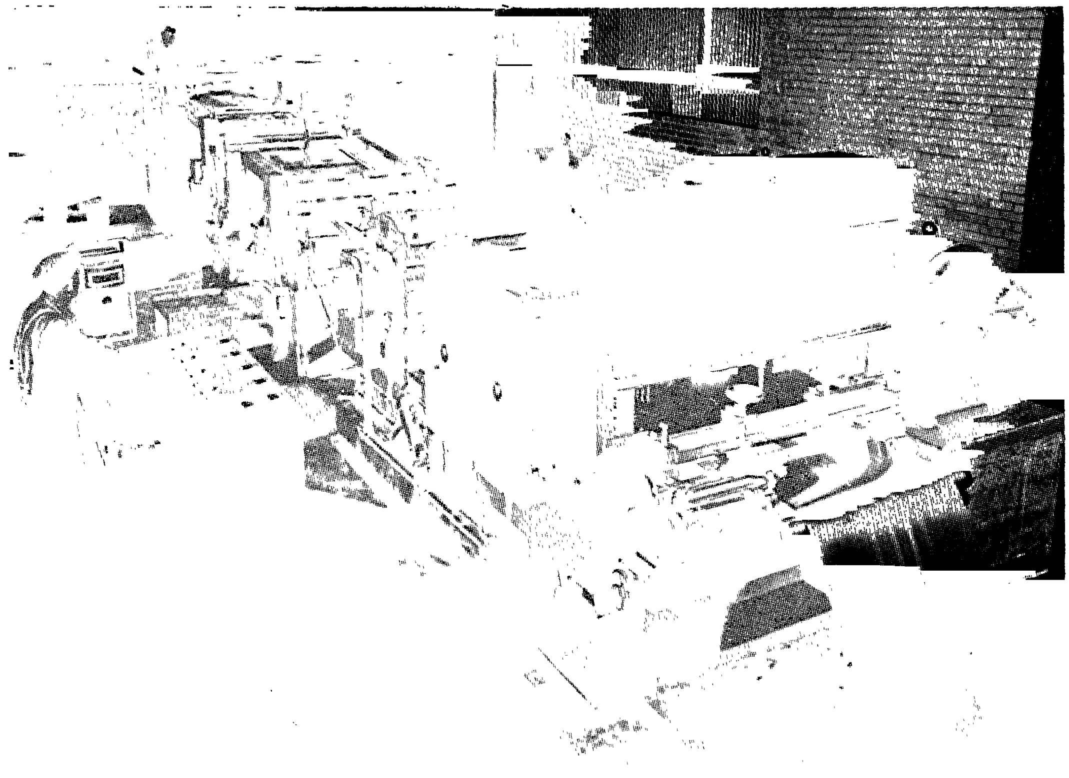
Fortunately, for the American iron industry, the first coal field to be developed was the anthracite, which, by its purity and hardness, served well for smelting purposes without being made into coke. Here was a factor that gave one region a heavy advantage over all others, and after 1840 we had a rapid concentration of the iron industry in the Schuylkill valley and other regions adjacent to the anthracite coal mines of eastern Pennsylvania. The old charcoal forges survived longest in locations remote from the places of superior manufacture, as in the southern Appalachians, where some of them were running for purely local supply as late as the year 1900.

The dominance of the Middle West. The supremacy of the eastern iron-manufacturing districts was shattered by the expansion of the American economy into the trans-Appalachian West. Here was an area of unmatched excellence for the development of the iron and steel industry. In the hill lands along its eastern border lay the Appalachian coal fields, rich in all qualities of bituminous coal and extending from western Pennsylvania to eastern Kentucky and into northern Alabama. To the northwest, billions of tons of high-grade iron ore lay awaiting discovery in the area around Lake Superior. Between these ore fields and the Appalachian coal stretched the Great Lakes to provide cheap transport for these bulky raw materials as well as favorable sites for lake-shore iron and steel centers. South and west of the Lakes lay the plains of the interior lowland—flat for the easy development of land transport, and fertile for the growth of an intensive agricultural economy. Beneath them lay substantial reserves of petroleum and natural gas as well as the interior coal fields of southern Illinois and western Kentucky.

Such a panoply of natural advantages, largely within a single country, is not to be found in any other part of the world. Here has developed the world's greatest concentration of steel-producing capacity, centered in the triangle whose corners are marked by Pittsburgh, Buffalo, and Chicago. Today the steel-making districts of this midwestern area account for over two thirds of our capacity.

The Pittsburgh-Youngstown district. Pittsburgh was the first center to develop in this area. The rapid expansion of railways

[1] Douglas A. Fisher, *Steel Making in America,* United States Steel Corp., New York, 1949, pp. 17–18. The ruins of the Saugus Iron Works have been excavated and the buildings and equipment rebuilt to serve as a museum.



A previous picture (Fig. 347) showed liquid steel pouring out of an open hearth. It is shaped in a mold, cools a little, goes to the rolling mill, and comes out in sheets like this—or railroad rails, ship plates, rods, pipe, wire, I beams, L beams for skyscrapers or fabricators.

The man at left moves small levers; a few hundred or thousand electric horse power do the rest. Might be Australia, West Europe, the U. S., or Canada. *Bethlehem Steel Co.*

before and after the Civil War increased the demand for iron, opened up the soft-coal fields of western Pennsylvania, and provided Pittsburgh with good railway connections with the older industrial markets of the East. It also enjoyed cheap water transportation afforded by a splendid location at a point where the Monongahela and Allegheny join to form the Ohio River. Coal in the nearby Connellsville basin was easy to mine and made excellent coke. By 1875 the 900,000 tons of coke-made iron in the Pittsburgh area exceeded in quantity that made with the more expensive anthracite coal.

Local iron ores were used at first, but Pittsburgh's real growth depended upon ore from the Lake Superior district. In 1854 ore was discovered in the Marquette Range near the western end of Lake Superior and shipments reached Pittsburgh the next year. Then followed the opening of the Menominee Range in 1877, the Vermillion and Gogebic in 1884, and the great Mesabi Range in 1892.

Easy access to Appalachian coal, to Superior ore, and to the markets and scrap iron of eastern America enabled Pittsburgh to take full advantage of the new processes for manufacturing steel. In the 1870's it became the greatest steel center in the United States and, later, in the world.

The predominance of Pittsburgh in American steel making was further enhanced by the formation of the gigantic United States Steel Corp. in 1901. From 1903 until 1948 this corporation pursued price policies that enabled products made in the Pittsburgh district to compete with products produced by newer steel plants throughout most of eastern Amer-

ica.[2] The corporation and its subsidiaries produce millions of tons of iron ore, coal, coke, limestone, and other materials needed in making steel. At the present time this corporation produces about one third of the nation's steel.[3]

TABLE 21:1. Distribution of Iron and Steel Capacity in the United States by Districts, January 1, 1954
(millions of tons)

	Pig iron	Steel ingots
Pittsburgh-Youngstown	29.5	46.7
Lake Erie[a]	14.2	19.0
Chicago-Gary	16.4	27.3
Total above	60.1	93.0
Eastern	11.8	17.4
Southern	6.3	6.9
Western	3.9	7.0
Total United States	82.1	124.3

[a] Lake-shore steel centers from Detroit to Cleveland.
Source: Computed from American Iron and Steel Institute data.

As the city of Pittsburgh is cut by valleys and gulches, level land available for factory sites became crowded years ago, and the iron and steel industry overflowed into adjacent territory. Around Pittsburgh developed a cluster of steel towns including McKeesport, Braddock, Carnegie, Homestead, and Johnstown. The industry spread northward up the Shenango valley to Sharon, Pa., up the Beaver-Mahoning Valley to Youngstown and into Canton, Massillon, and other eastern Ohio towns. It also spread down the Ohio River to Weirton, Steubenville, Wheeling, Huntington, Ashland, Ironton, and Portsmouth, and up the Miami Valley to Middletown. Pittsburgh and its industrial satellites now manufacture about 35% of the nation's steel, or about as much as the postwar output of Great Britain, Germany, and France combined.

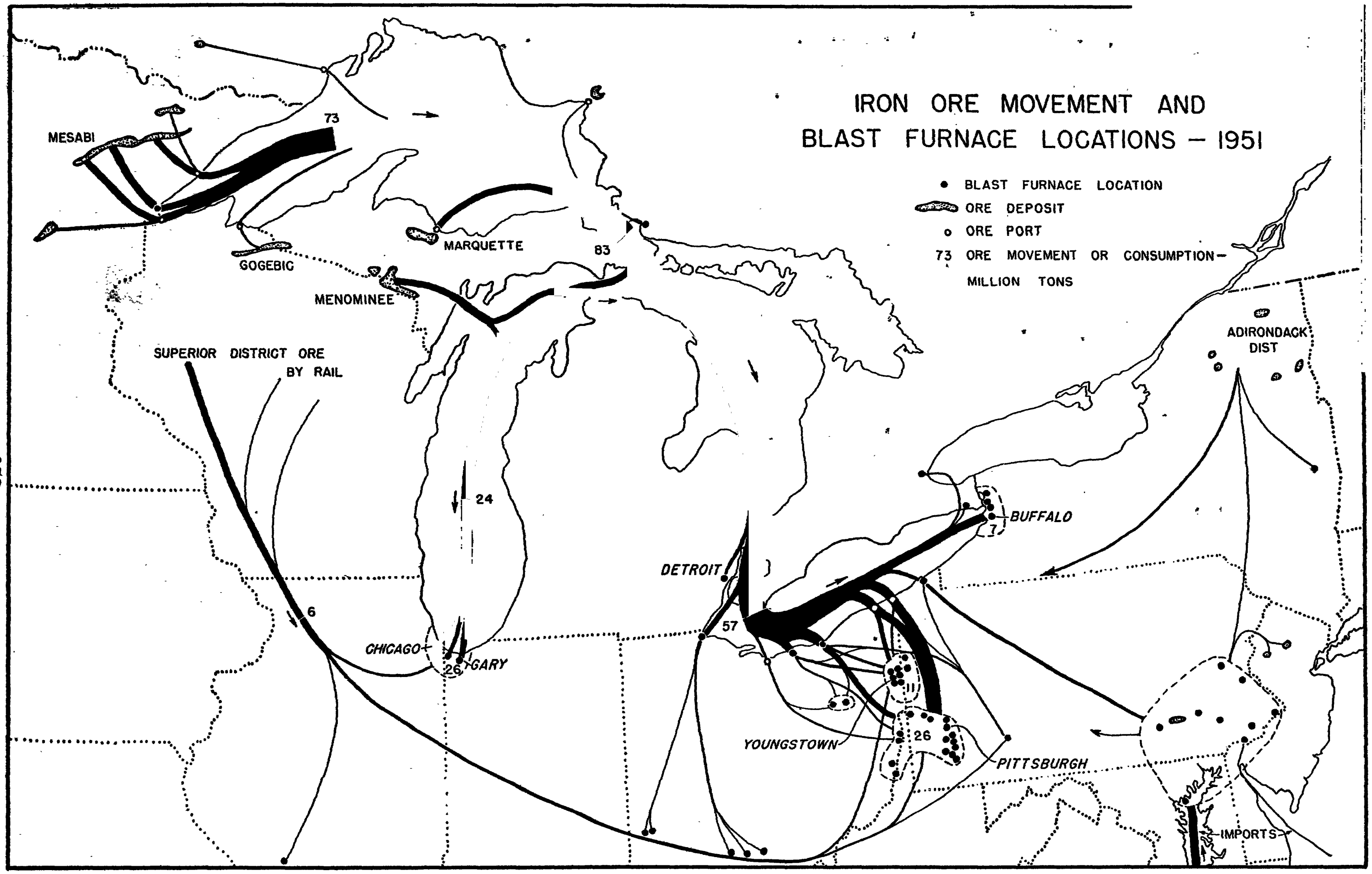
The Great Lakes districts. The supremacy of Pittsburgh did not remain long unchallenged, for the twentieth century witnessed an important migration of the iron and steel industry to the southern shores of Lake Erie and Lake Michigan. As early as 1900, the Lackawanna Steel Co. recognized the value of a lake-shore site, where the ore steamer could unload its cargo alongside the blast furnace, and moved its plant from Scranton, Pa., to a suburb of Buffalo. Along the Lake Erie shore today steel plants are located at Buffalo, Erie, Cleveland, Lorain, and also at Detroit to serve an important industrial market. From several of these ports the ore trains run southward and return with coal, which makes the freight rates lower in both directions.

The southern shore of Lake Michigan offers similar advantages and access to an even larger market area to the west and south. In 1907 the United States Steel Corp. laid out the town of Gary, Ind., and set up a huge steel plant at this point, where Superior ore meets coal from southern Illinois and the Appalachian fields. The world's two largest steel plants are now located in this Chicago-Gary district, which is Pittsburgh's leading rival. On the level plains that border Lakes Michigan and Erie is ample room for expansion, and steel mills have an ample supply of industrial water.

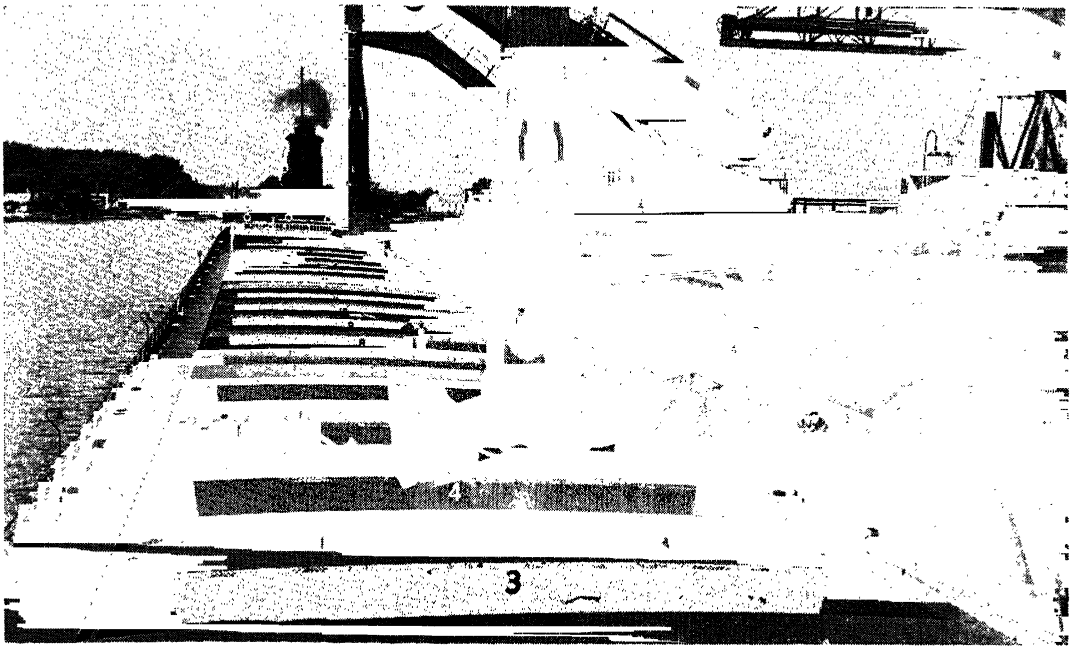
Specially built ships carry huge cargoes of iron ore at low cost from the head of Lake Superior to the big steel plants along the southern shores of Lakes Michigan and Erie. Indeed, the cost of moving a ton of iron ore

[2] From 1903 until 1924 the corporation pursued a price policy known as "Pittsburgh plus." Under this policy consumers outside of the upper Ohio Valley were charged the price prevailing in Pittsburgh plus freight charges from Pittsburgh. Thus, if a consumer in Montgomery, Ala., purchased a product from a Birmingham plant that produced it at a lower cost than in the upper Ohio Valley, he had to pay the Pittsburgh price plus a charge for freight, as though the product had been shipped from Pittsburgh. This policy was prohibited by the Federal Trade Commission in 1924. The corporation immediately established a multiple-basing-point policy that was merely a modification of the "Pittsburgh plus" system, and in 1948 this new policy was declared illegal by a decision of the United States Supreme Court in the "Cement Case." All prices are now quoted f.o.b. mill.

[3] See Douglas A. Fisher, *Steel Serves the Nation, 1901–1951, The Fifty Year Story of United States Steel,* United States Steel Corp., New York, 1951.



Blast furnace locations over 80% of U. S. and Canada. Omitted are Nova Scotia, U. S. South and West. St. Louis and Ohio River locations approximate. Compare coal map (Fig. 271 bottom) and Chapter 33. U. S. ore import 7 million tons, 1951. Estimated 20 millions in 1955. Compare Pittsburgh-Youngstown with Chesapeake-Delaware. *Adapted from Lake Superior Iron Ore Association map*



Lake ore boat; freight cars alongside; Hulett type unloader; operator inside (see his head); 17-ton load. Average unload 21,000 tons in 12 hours. Mechanism at upper right is part of lifter. ***Wellman Engineering Co., Cleveland***

800 or 900 miles by water from Duluth-Superior to Lake Erie ports is less than the cost of carrying it 100 miles by rail from Lake Erie to Pittsburgh. Likewise, the heavy limestone needed as a flux is brought cheaply in ships from the quarries at Calcite and Alpena, Mich. Finished steel products are distributed quickly and at reasonable cost over a dense network of railroads and highways that serve a large and productive hinterland. With such excellent transportation facilities and with a prime location in the midst of big cities and many factories, these lake-shore steel-making plants are well able to serve a splendid market. In recent decades no other area has equalled the progress achieved by the Great Lakes steel-making districts, which now equal the capacity of the Pittsburgh-Youngstown area (see Table 21:1 and Fig. 358).

The steel plant at Duluth is an outpost of the Great Lakes district that can assemble materials cheaply. Iron ore is near at hand. West Virginia and Pennsylvania coal is delivered at exceptionally low rates by vessels that are eager to carry coal up the Great Lakes rather than travel in ballast. Duluth's disadvantage is a small market, and steel production remains small.

The iron-ore ranges around the head of Lake Superior mean much to United States'

TABLE 21:2. Supply of Iron Ore in the United States in 1950
(millions of short tons)

From	To the lower Lakes area	To the East	To the South	To the West	Total
Lake Superior	85	6	..	..	91
Northeast	2.5	2.5	..	..	5
South	..	..	11	..	11
West	..	..	..	5	5
Canada	2	..	..	..	2
Chile	..	3	..	..	3
Other sources	1	3	..	..	4
Total	90.5	14.5	11	5	121

Source: The President's Materials Policy Commission, *Resources for Freedom,* Washington, Vol. 2, 1952, p. 14.

three greatest steel-making districts (see Table 21:2). These ranges normally produce 80% of all the iron ore mined in this country, and in 1953 they yielded the staggering total of

108 million tons. Three fourths of the output of the Lake Superior district comes from the great Mesabi Range. The word *Mesabi* in the Chippewa Indian language means giant, and this giant has produced about 1¾ billion tons of iron ore to date. In contrast with the other ranges, where underground workings predominate, the ore of Mesabi is easily obtained by open-pit mining methods.

As a result of past digging, the Mesabi ore pits are now large enough to contain several football stadiums and deep enough to hold a building 30 stories high. Far down in these man-made canyons giant electric shovels grab as much as 16 tons of ore at a single bite, dumping the ore into heavy-duty motor trucks or onto conveyor belts, which carry the ore to railway cars that transport the ore from the floor of the pits to the ore docks at the twin ports of Duluth and Superior. When the cars reach the top of these high docks, the hopper bottoms are opened, and the ore slides by gravity into storage bins and thence by chutes into the cargo hold of a lake vessel at the rate of 100 tons per minute. When the hatch covers are pulled back for loading or unloading, the ship resembles an open barge, but it may hold as much as 21,000 tons of iron ore. When the vessel arrives at destination, huge clam-shell buckets unload the ore within a few hours. From ore pit to blast furnace, "up by electricity or steam and down by gravity" is the common rule of practice.

Unfortunately for the iron and steel plants in the Great Lakes district, the bonanza of low-cost ore cannot last forever. It is estimated that Mesabi's reserves of high-grade, low-cost ores will be exhausted within 20 or 25 years if production continues at the present rate.[4] Over three fourths of the ores now being mined in the Lake Superior region have an iron content of 50% or more, and these can go to blast furnaces without processing. Ores that contain 35% to 50% iron must be washed and treated to remove the silica. Even lower grades of ore are now coming into use.

The Lake Superior region has tremendous quantities of taconite, an extremely hard rock material containing 25% to 35% iron (see Table 21:3). Mesabi alone has at least 1½ billion tons of magnetic taconite that can be obtained from open pits. In 1954 plants at Aurora and Iron Mountain, Minn., were engaged in pulverizing taconite, extracting iron concentrates by use of magnets, and producing walnut-sized pellets of ore. These pellets, containing about 65% iron, make better pig iron than ores now in use, but they are more costly. Other taconite-processing plants are being built and involve a capital investment of more than $1 billion.[5]

TABLE 21:3. Reserves of Iron Ore in the United States
(billions of long tons)

Region	50% iron and over	35% to 50% iron	25% to 35% iron	Total
Lake Superior ..	1.6	2.5	60.0	64
Northeast	..	..	3.0	3
South	..	1.8	9.5	11
West	.5	.1	.2	1
Total[a]	2	4	73	79

a Since estimates have a crude margin of error, totals are expressed in round numbers.
Source: The President's Materials Policy Commission, *Resources for Freedom,* Washington, Vol. 2, 1952, p. 14.

Eventually the iron and steel plants in the Great Lakes district must find a way to use large amounts of low-grade ores from the Superior region, or they must import high-grade ores. The recently begun Great Lakes–St. Lawrence Seaway will eventually permit large vessels to deliver cargoes of rich ore from the mines of Labrador, Newfoundland, Venezuela, and other lands.

Steel manufacture along the Middle Atlantic seaboard. The East remains a sig-

[4] U. N., Department of Economic Affairs, *World Iron Ore Resources and Their Utilization,* Lake Success, N. Y., 1950, p. 14, and The President's Materials Policy Commission, *Resources for Freedom,* Washington, Vol. 2, 1952, p. 14.

[5] "Taconite Boom," *Time,* April 28, 1952, pp. 92, 94; The President's Materials Policy Commission, *op. cit.,* pp. 14–15; and American Iron and Steel Institute, *Steel Facts,* April 1954, p. 4.

This ornament from Bethlehem Steel Co. office shows ore routes to Cuba, Venezuela, Chile, and other company lines.

nificant and growing steel district, with its important centers in Maryland and Pennsylvania in the area between Baltimore, Harrisburg, Bethlehem, and Trenton, N. J.[6] These centers represent two periods in American steel history. Inland centers, of which Bethlehem is the largest, are located along the rivers draining the anthracite coal fields and reflect the time when this was the major iron and steel district.

More recently larger plants have been built on tidewater. The Bethlehem Steel Corp.'s

[6] Johnstown and Erie, Pa., and Buffalo, N. Y., are often included in the "eastern district" but are here considered to belong in the districts depending upon Superior ore and Appalachian coal.

plant at Sparrows Point, near Baltimore, rivals those of Gary and South Chicago in size, and for years it was the only large (5.7 million ton capacity) steel plant on tidewater. A second tidewater plant, built by the United States Steel Corp. at Morrisville across the Delaware River from Trenton, began operations in 1953 with a capacity of 2.2 million tons. The National Steel Corp. is building a third plant on the east bank of the Delaware near Camden.

While these eastern mills depend upon the Appalachian fields for their coal supply, the ore comes from various sources. Ore from the Superior district reaches them by rail from Lower Lake ports, with eastern mines, especially in the Adirondacks, an additional source. Foreign ore makes up over half the supply for the eastern mills, and its importance will increase. The chief sources have been Sweden and Chile, with smaller amounts from Brazil, Liberia, Spain, and North Africa. Recently shipments have begun from the huge new deposits being developed in Labrador and at Cerro Bolivar and El Pao in Venezuela, which will probably become major sources of foreign ore for the Great Lakes as well as coastal steel centers (see page 344, footnote 6).

These steel plants, at or near tidewater, are thus able to draw raw materials from many parts of the world and similarly to ship finished products by water to other parts of the United States and abroad. In addition they are in the midst of a highly industrialized area with its local market and scrap supply.

The steel industry in the South. In northern Alabama, Birmingham—named for the iron and steel city of England—possesses a rare combination of resources for iron and steel production. No other locality has such a natural assemblage of raw materials. Strata of iron ore and limestone lie one above another in Red Mountain on the east slope of Jones valley. The iron ore contains about 15% lime and is nearly self-fluxing. Luckily coal mines are but a few miles away.

Offsetting Birmingham's great raw-material advantage is its chief handicap, the lack of an industrial market, for the South remains primarily an agricultural region. Furthermore, most Birmingham ores have an iron content of only 30% to 40%, and hence more ore and coal must be used to produce a ton of pig iron. The ore lies deep beneath the surface and is harder than Superior ore, which makes much drilling, blasting, and crushing necessary. Because of its high phosphorus content, pig iron must be subjected to both basic Bessemer and basic open-hearth processes, this duplex process raising the cost of finished steel.[7] Birmingham's ore imports, chiefly from Venezuela, have risen sharply since the war to 900,000 tons in 1953, with the expectation of 3 million tons annually in the near future.

The only other southern steel area of significance is Texas where wartime expansion has brought steel-ingot capacity to 1.8 million tons. Integrated plants are located at Daingerfield and, on tidewater, at Houston. Local ore is supplemented by imports to produce steel for the growing industrial market along the Gulf Coast and in the Southwest.

Steel making in the West. Although the capacity of western steel plants has trebled since 1939, they produce less than 6% of the nation's steel. The iron and steel industry of the West is largely subsistence manufacturing, serving local and limited markets.

The first steel plant in the West was erected at Pueblo, Colo., in 1882. It is now supplied with iron ore from southeastern Wyoming and western Colorado and with good heating and coking coal from southern Colorado. Steel made at Pueblo is used in the manufacture of railway rails, mining machinery, farm implements, and various foundry and machine-shop products that are sold throughout the Rocky Mountains and the western plains.

During World War II the United States Steel Corp. built and operated a steel plant for the federal government at Geneva near the city of Provo, Utah, to help provide steel for the

[7] For a detailed discussion of southern steel manufacture, see Herman E. Chapman and others, *The Iron and Steel Industries of the South,* University of Alabama Press, University, Ala., 1953.

shipyards, ordnance plants, and factories along the Pacific Coast. (In 1946 this $200-million plant was sold to the corporation for $47½ million.) It is supplied by iron mines 255 miles to the southwest, coal mines 120 miles to the southeast, and limestone quarries 35 miles to the south. Since Utah is not a large market, much steel and some pig iron is shipped to the Pacific Coast.

California, with nearly half of the West's capacity, had no blast furnaces prior to 1940. Semi-integrated plants, with steel furnaces and rolling mills, were located in the vicinities of Los Angeles and San Francisco. Raw materials were pig iron from Utah and scrap, much of which came through the Panama Canal from the East Coast. Since then an integrated iron and steel plant, built by the U. S. government, has doubled California's capacity. Located at Fontana, east of Los Angeles, it serves the nation's most rapidly expanding industrial center, but most of the coal and some of the ore must be shipped by rail from Utah.

Future location in the United States. While it is correct to speak in general terms of a "steel region" extending inland from the Atlantic coast to Chicago and St. Louis, our discussion has showed that steel production is concentrated at centers *within* this region which, for convenience, we have grouped into districts. It is at these centers that the locational factors—access to coal, ore, and market—have been most favorable, and their number, particularly of the larger ones, is limited. Four districts—Chicago-Gary, Lake Erie, Pittsburgh-Youngstown, and the East Coast—still account for nearly 90% of the nation's steel capacity, despite the rapid expansion in South and West. But there are indications of some change.

A major feature has been the relative decline of the Pittsburgh-Youngstown district, where steel capacity increased by only 20% (1941–54) while capacity in the United States as a whole increased 55%, from 86 to 124 million tons. During this period steel capacity of the centers along Lake Erie increased by two thirds, while Chicago-Gary and the eastern centers expanded by 50%. While still the leading steel-making district in the world, Pittsburgh-Youngstown is losing its dominant advantages. Coal has become less of an attractive force; some of the high-grade Connellsville seams are being depleted; and coke can now be made from a variety of coals from various areas. Also, scrap tends to be more expensive at Pittsburgh, and this further favors more rapid expansion in the steel-producing and market centers along the Lakes and the East Coast.[8]

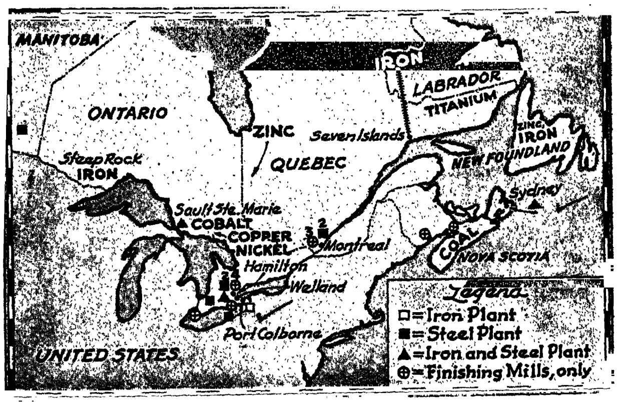
Our increasing dependence on foreign ore may also affect location of the industry. From a prewar average of 2.3 million tons our ore imports have risen to 16.0 million tons in 1954. By 1970, 41 million tons of the estimated 119 million tons of ore needed for capacity operations may come from foreign sources, mainly Labrador and Venezuela.[9] This will certainly reduce the disadvantage of coastal areas where ore has been limited or expensive. Nevertheless, the St. Lawrence Seaway will bring foreign ore economically to the Great Lakes steel centers, and the Superior district will remain our chief source of ore and taconite. The major concentration of our iron and steel industry will remain in the Pittsburgh and Great Lakes districts, although their dominance may decline somewhat and changes in relative importance among the various producing centers will continue. The iron and steel industry is notably stable and slow to change its location.

3. CANADIAN IRON AND STEEL

Canada's steel centers. The Canadian iron and steel industry owes its origin to generous

[8] See Walter Isard and William Capron, "The Future Locational Pattern of Iron and Steel Production in the United States," *Journal of Political Economy,* April 1949, pp. 118–133.

[9] According to this estimate, domestic sources in 1970 will be: Lake Superior ore, 34 million tons; taconite concentrate (also from Lake Superior), 25; and other domestic ore, 19 million tons. Statement of Dr. James Boyd, U. S. Bureau of Mines, April 17, 1950.



Some of Canada's well placed metals. Note importance of Great Lakes to industrial Canada. ***American Iron and Steel Institute***

government bounties, its continued existence to tariff protection, and its recent expansion to wartime demands and postwar prosperity. The capacity of Canada's steel furnaces (4.7 million tons per year) is about as small in comparison to that of the United States as is the Canadian market (population 14 million), and Canada imports about one fourth of its supply of steel products.

The larger two of Canada's three steel-making centers are in the Great Lakes area[10] —one at the port of Hamilton on Lake Ontario and the other at Sault Ste. Marie between Lakes Superior and Huron. The plants at Hamilton, the largest in Canada with a capacity of over 2 million tons, are well located to serve the industrial centers of the Ontario peninsula and the upper St. Lawrence Valley. Both Hamilton and Sault Ste. Marie have easy access to Canadian and U. S. ores near the head of Lake Superior, and both are dependent upon Michigan limestone and Appalachian coal.

The third center, on tidewater at Sydney, Nova Scotia, produces about one fifth of Canada's steel. Few steel plants have better access to materials and fuel. Excellent coal is mined locally. Ore and limestone are obtained cheaply by water from Newfoundland, where the iron mines are also on tidewater near St. Johns. Finished steel can be shipped to the cities of the upper St. Lawrence Valley, but unfortunately the United States tariff wall stands between Sydney and the large industrial markets of New England.

Ore exports. Canada has long exported iron ore to the United States, from its Great Lakes fields. Shipments have begun from the huge deposits in the wilderness along the Quebec-Labrador border 300 miles north of the St. Lawrence port of Seven Islands. This will make Canada a major source of foreign ore for the U. S. steel industry, while Canada's own industry, though expanding, will probably remain of modest size.

4. THE BRITISH IRON AND STEEL INDUSTRY

Growth of foreign competition. In 1850 Great Britain produced half of the world's iron and 70% of the steel. Following the discoveries of Bessemer, Siemens, Martin, Gilchrist, Thomas, and others, it was Great Britain that led the world out of the age of wrought iron and high-cost steel into the modern era of large-scale steel production. But in the process Britain lost its dominance, because the new technology could be used in competing areas to develop greater resources and serve larger markets than those available to British steel makers. Indeed, Great Britain has been surpassed by the United States since 1890, Germany from 1894 until after World War II, by the Soviet Union since 1934, and in occasional years by France (see Table 21:4). Although producing only about 8% of the world's steel at the present time, Britain's industry has expanded and is on a sound producing basis.

Shifts in location. Changes in location have accompanied the industry's technological development, even in this small island. As we have seen, the use of coke drew the iron industry from the forests to the coal fields (p. 345). "Black band" iron ore interbedded in the coal measures of South Wales, Scotland, and the

[10] See James E. Payne, "Canada Unlimited," *Steelways*, September 1952, pp. 1–4.

Birmingham area gave these districts an added advantage, and by 1850 they produced about three fourths of Britain's iron.

The Bessemer process, with its initial requirement for phosphorus-free ore, stimulated the development of steel plants on the northwest coast, near England's only deposits of high-grade ore. More important, however, was the advantage given to coastal locations where ore from Sweden, Spain, and North Africa could be cheaply imported. South Wales and Scotland benefited and also the northeast coast, where Middlesbrough rose rapidly in importance after 1860. Middlesbrough also drew on the nearby iron ore in the Cleveland hills.

Two other major deposits of Jurassic ore, lying to the south and somewhat inland, in Lincolnshire and Northamptonshire, were developed later and on the basis of the basic open-hearth process.

Principal British steel-making districts. The present location of the British steel industry thus reflects its past development as well as the contemporary influence of markets and raw material sources. Fundamental is the fact that for decades Britain has imported about half of its ore supply, since the Jurassic ores, which now account for over 95% of Britain's production, have an iron content of only 20% to 35%.

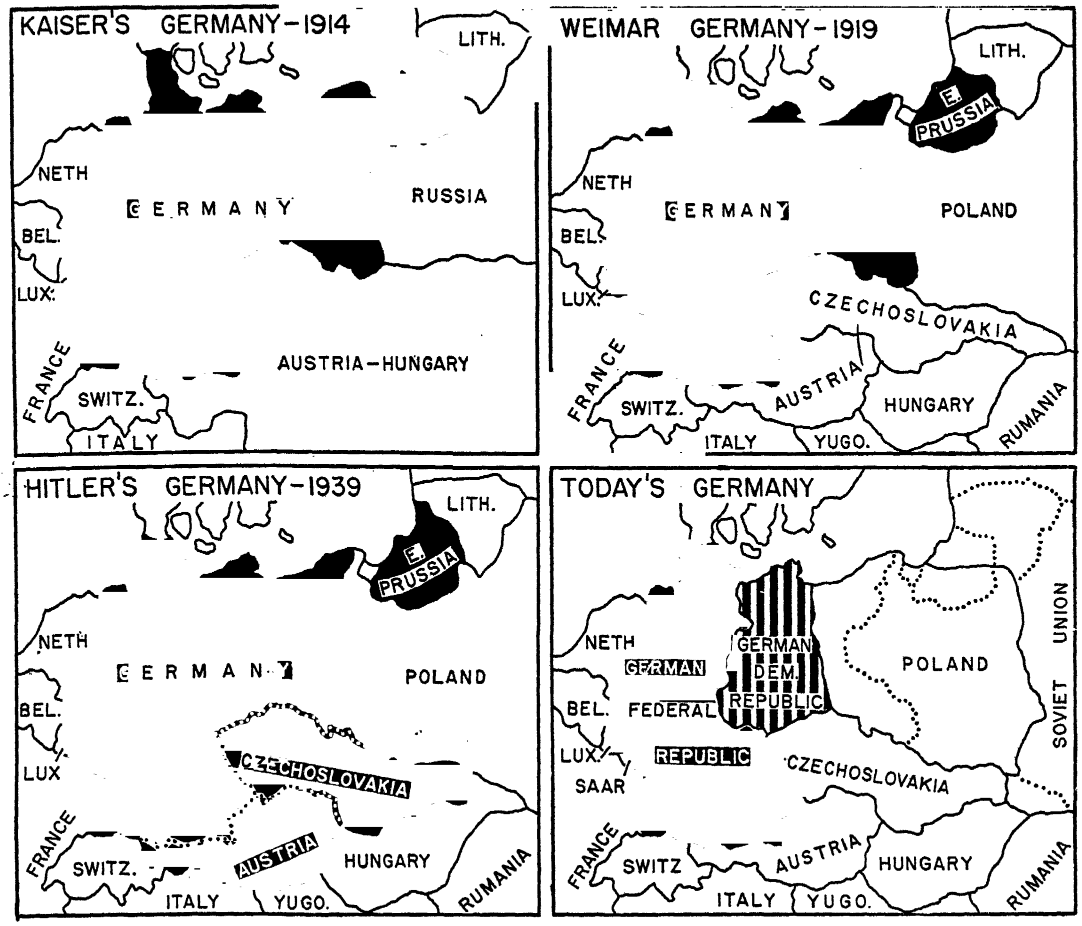
Fortunately, these ore fields are close to the excellent coals of the Yorkshire and Durham-Northumberland fields lying on the east side of the Pennines. Steel centers in this eastern portion of England account for about half of Britain's production. Middlesbrough, long the country's leading steel center, is the most important. Located at tidewater and between Cleveland ore and Durham-Northumberland coal, its situation is excellent for the assembly of domestic materials and imported ore. To the north are the shipbuilding and heavy-machinery industries around Newcastle, and steel products can also be shipped by water to other parts of Britain and abroad. The newer steel mills on the interior ore fields at Scunthorp (Lincolnshire) and Corby (built during the 1930's in Northamptonshire) use little imported ore and obtain coal from Yorkshire. Sheffield, another old center situated on the Yorkshire coal field, represents the third type of steel location in this eastern area. It specializes in the production of quality steels and produces little pig iron. Some pig iron comes from the centers nearer the coast and much scrap is used. Birmingham, in the Midlands at the southern end of the Pennines, is a similar type of location.

Since World War II South Wales has displaced Middlesbrough as Britain's leading single steel district. The inland Ebbw Vale plant was built during the 1930's, but most of the mills are on the coast, convenient to South Wales coal, imported ore, and water shipments of products. Swansea and Cardiff are old centers, and the recently completed plant at Port Talbot is said to be the largest in Europe.[11] Other important steel-making districts are located along the west coast: in the Clyde River shipbuilding area in the western Scottish Lowland, at Barrow near the small Cumberland ore field, and near Liverpool.

5. IRON AND STEEL PRODUCTION IN WESTERN EUROPE

The industrial triangle and the political factor. The heart of the steel industry of western Europe lies in a triangle that straddles the borders of France, Germany, Holland, Belgium, and Luxembourg. Its eastern corner is the Westphalian industrial district of Germany where the Rhine gives easy access to the sea, and the Ruhr is the largest and best coal field in Europe. To the west another coal field, the Sambre-Meuse, extends from northeastern France across Belgium and into southern Holland, with smaller fields between it and the Ruhr. The southern corner is the Lorraine iron-ore field of eastern France, with

[11] Erich W. Zimmermann, *World Resources and Industries*, rev. ed., Harper & Brothers, New York, 1951, p. 672. What other location has good coal beside a good harbor to unload coal?



Germany? What do you mean by the term? Here we see quick shufflings of history.

the Saar coal field on the Franco-German border just to the east (see Fig. 370).

In continental Europe industrial development has long been confronted with the uncertainty arising from the vicissitudes of war, shifting international boundaries, and the vagaries of tariff making. Bullet wars and tariff wars make costly readjustments necessary. In any appraisal of the European iron and steel industry, the unstable political factor in the equation of industrial development is too important to be ignored (see Fig. 367).

The German iron and steel industry. Two notable gains from the Franco-Prussian War set the stage for rapid and large-scale industrial development in Germany. One was national unity achieved by the creation of the German Empire at the conclusion of the war in 1871, which brought the formerly independent and semi-independent German states under the control of a strong national government. The other gain was Alsace-Lorraine, which victorious Germany acquired from France. In Lorraine are the largest iron-ore reserves in all of Europe, located 150 miles south of the excellent coking coals of the Ruhr Valley, truly a grand prize for steel making. Luckily for Germany, the perfection of the basic Bessemer process in 1878 made it possible to remove the undesirable phosphorus from the Lorraine ores, and between 1880 and 1913 the German steel output increased from 690,000 to 17,320,000 long tons.

The Rhineland-Westphalian area, includ-

ing the Ruhr, became the most highly industrialized area and greatest steel-making district of continental Europe; and secondary steel-making centers developed in the Saar Basin and Upper Silesia, both being well endowed with coal. A considerable manufacture of iron and steel also developed in Lorraine, since trains moving northward with iron ore could return filled with Ruhr coal and coke. Such large steel-making centers as Essen, Bochum, Gelsenkirchen, and Solingen—indeed all the great manufacturing cities of Germany—are served by a veritable labyrinth of railroads, canals, and navigable rivers that move heavy freight in almost every direction. The Rhine River is one of the world's busiest waterways and provides the Rhineland-Westphalian industrial area with cheap access to the sea.

World War I dealt a heavy blow to the German iron and steel industry, as the return of Alsace-Lorraine to France, the cession of part of Upper Silesia to Poland and Czechoslovakia, and the loss of the Saar Basin for 15 years deprived Germany of about 70% of her iron ore and 12% of her coal reserves. In terms of prewar output, Germany lost areas that produced more than three fourths of her iron ore and nearly one third of her coal, and that contained about one third of her steel works and rolling mills.

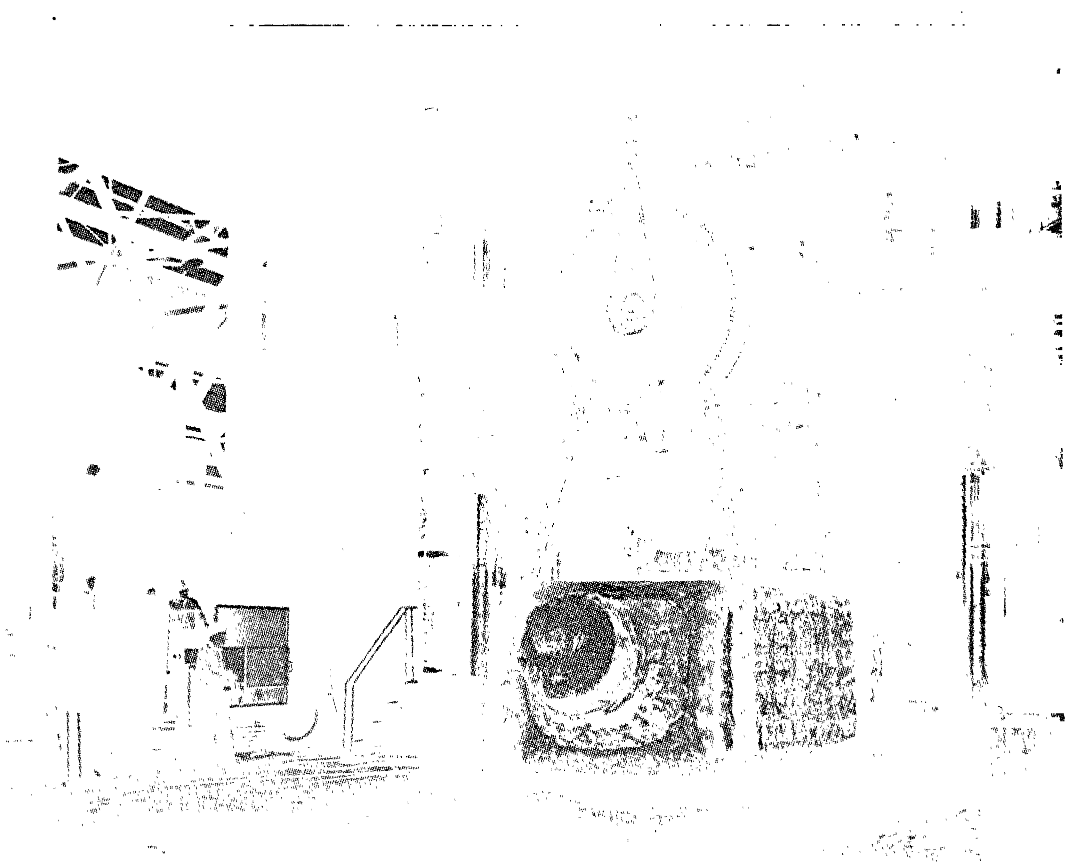
After World War I Germany rebuilt and modernized her steel industry. The lean domestic ore supplies were exploited intensively and Sweden became even more important as a source of foreign ore. Mergers reduced competition in the German steel industry, and cooperation was achieved with other European producers through a gigantic International Steel Cartel. By 1924 Germany was again the world's second steel producer and in 1939 her steel output reached an all-time peak of 24 million tons (see Table 21:4).

World War II was a second blow to German steel. Wartime destruction, postwar dismantling, and Allied control reduced production in the Ruhr. Silesia went to Poland, the Saar to France, and Germany itself was divided with little trade between East and West. In recent years the industry in West Germany has again been rebuilt with production in the Ruhr approaching its prewar level. But the 1953 production was 15 million tons, in contrast to the 24 million tons of the larger, prewar Germany. As before, about two thirds of the ore supply is of foreign origin.[12] Past experience demonstrates that in times of peace the German industry has cheap and easy access to ores of France, Sweden, and other lands.

France and the Saar. In contrast with Germany and Great Britain, which have long been rich in coal and are now vitally dependent upon foreign iron ore, France is rich in iron but has long been the world's greatest importer of coal. The return of Alsace-Lorraine in 1918 doubled French iron-ore reserves, and France soon became the world's second largest producer and the leading exporter of iron ore. About half the French output of iron ore is usually exported, 95% of the exports moving by rail to the nearby steel-making districts of Belgium and Germany.

On the other hand, rising costs of domestic coal and the increasing demands of industry make it necessary for France to import about one third of its coal supply. Little French coal is good enough to be used in the manufacture of coke, and most of the coke consumed by the French iron and steel industry is either imported or is produced locally from imported coking coals. In prewar years Germany and Great Britain were the chief sources of imported coal. In the postwar era the decline in British and German coal production has made it necessary for France to purchase costly U. S. and Polish coal in addition to using coal and coke from the nearby Ruhr and Saar. These facts clearly indicate that the basic

[12] The total iron content of Germany's probable iron-ore reserves is estimated at approximately 0.26 billion metric tons. German ores have an average iron content of 32%; those of France, 38%; Sweden, 64%; Spain, 45%; Newfoundland, 48%; and Algeria, 50%. U. N., Dept. of Economic Affairs, *op. cit.*, pp. 66–67.



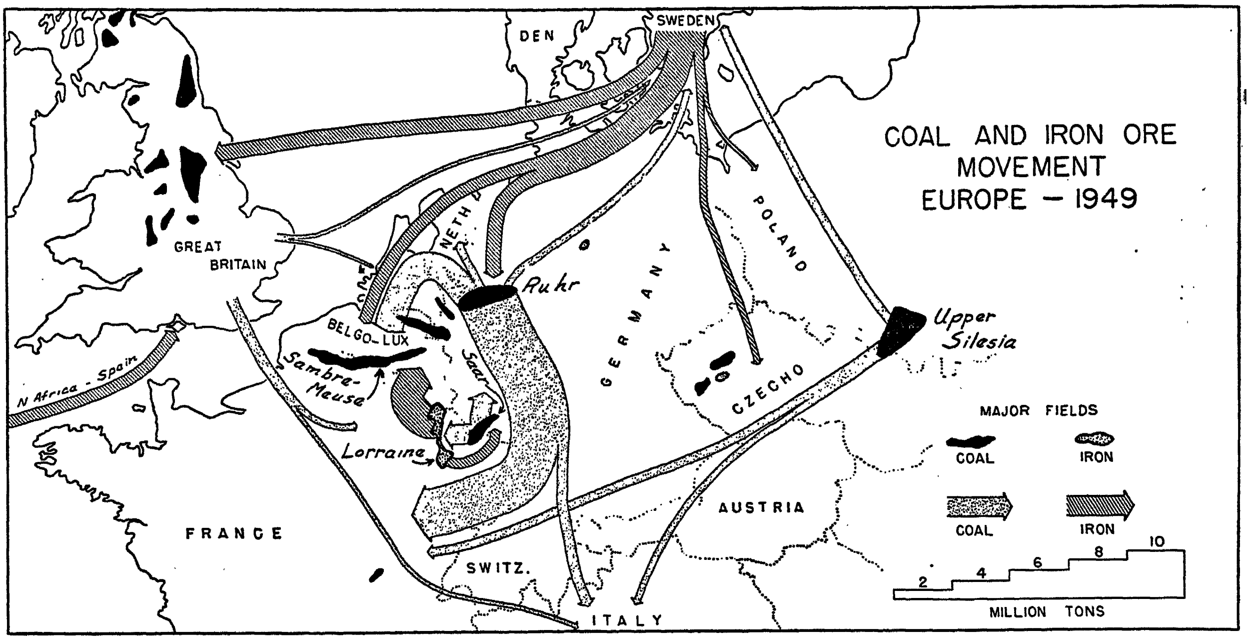
"Under a spreading chestnut tree the village smithy . . ." His successor, this 7500-ton press, shapes bigger pieces of metal than the poet Longfellow ever imagined 100 years ago. Operator at left plays his little piano of levers to make this titan work. *Bethlehem Steel Co.*

steel-making resources of France and those of her neighbors are highly interdependent.

By far the most important steel-making district of France is the Lorraine Basin, which manufactures about three fourths of the nation's pig iron and steel. As this area is not well endowed with coal, it draws heavily upon the excellent coal and coke of the German Ruhr. The Lorraine iron-ore deposits yield about 95% of the total output of France, and most of them are easily worked by open-pit methods. Because of their high lime content, these oölitic limonite ores do not require the addition of limestone as a flux, but their high phosphorus content makes the basic Bessemer and basic open-hearth processes necessary in steel making. Blast furnaces and steel plants are situated in the vicinity of the iron mines near Metz, Briey, Nancy, Thionville, and Longwy. Some of the crude steel is shipped to plants in other parts of the country, such as the great armament plant at Le Creusot.

Another steel-making district is found in the Sambre-Meuse coal-mining area of northern France, near the seaboard for coal and coke from Great Britain and the Netherlands. Iron ore is secured from Normandy, Luxembourg, and Lorraine. As this steel-making district lies in the midst of a great industrial area, large amounts of scrap metal are available and are used in the manufacture of steel. Valenciennes, Denain, Haumont, and Jeaumont are the leading steel-making centers.

In 1953 France produced nearly 10 million long tons of steel, excluding the Saar's output of 2½ million tons. The steel-making industry of the Saar is based upon local coal and coke and the iron ore of Lorraine and Sweden.



All movements above 1 million tons. Flow lines, not actual routes. Note central location of industrial triangle—Sambre-Meuse, Ruhr, Lorraine; national interdependence. ***British Iron and Steel Federation***

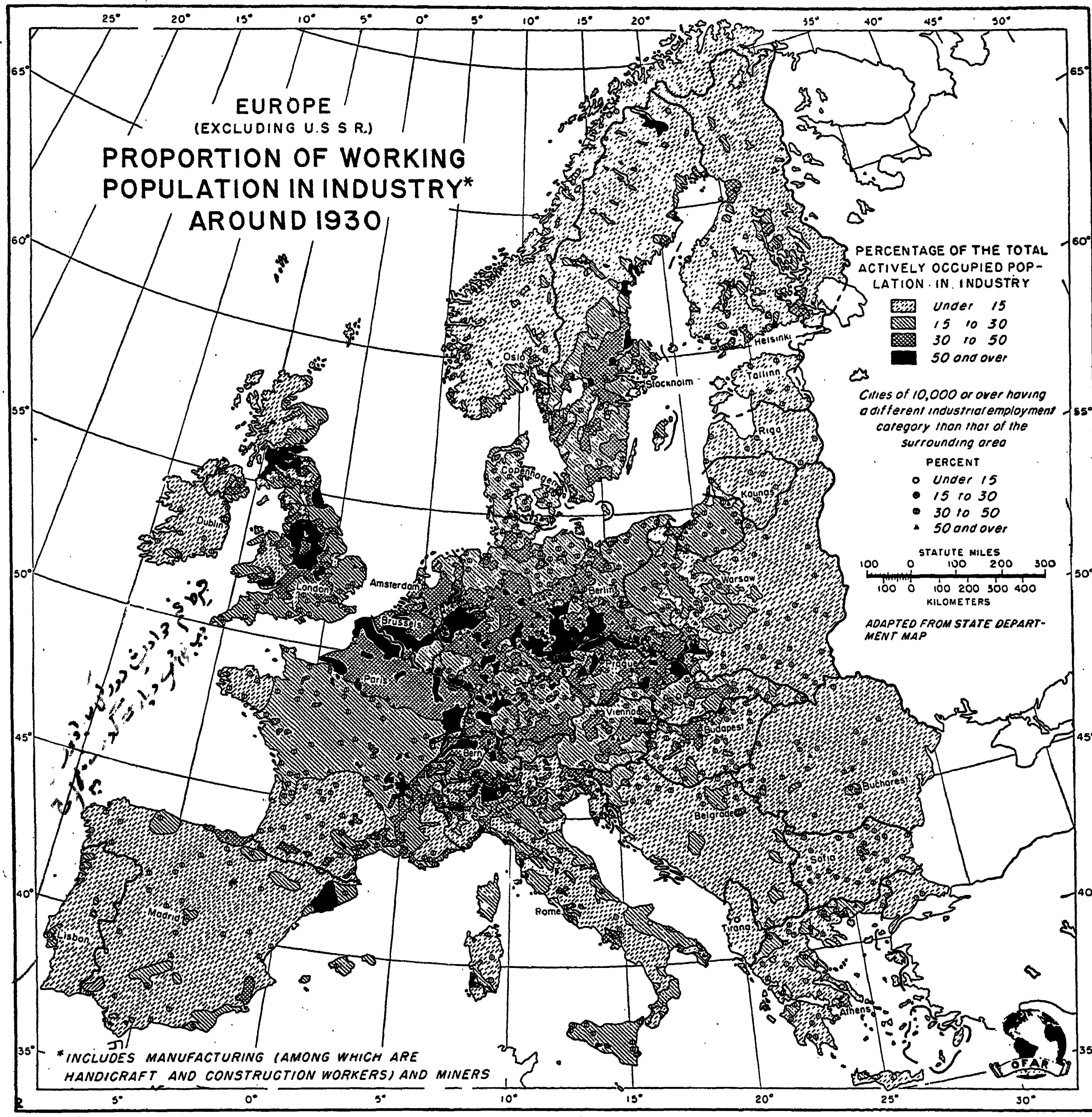
Both France and West Germany covet this tiny, coal-rich state that lies along the international boundary just east of the great iron ore deposit of Lorraine. At present the economy of the Saar is merged with that of France. No tariffs impede trade between them. The Saar has political autonomy, but its resources and industrial output are under French control.[13]

Belgium, Luxembourg, and the Netherlands. The boundary between Belgium and Luxembourg is a frictionless line with no tariff barriers since the two countries were joined together in a customs union in 1922. This sensible arrangement, permitting complete freedom of trade, promotes the effective use of the natural resources of both countries and has stimulated the manufacture of iron and steel. Although Belgium has coal and Luxembourg has iron, most of the iron ore and much of the coke consumed must be imported. As the combined area of these two countries is not much larger than that of Maryland, short hauls facilitate the assembly of raw materials and the distribution of finished products. Belgium and Luxembourg together rank seventh among the steel-making nations of the world, and about half their steel output is exported.

The Netherlands is an exporter of pig iron and an importer of steel. The nation's only steel plant is located at Ijmuiden at the seaward end of the North Sea Canal. It produces about 600,000 tons a year. This plant is supplied with Dutch coal and coke and with Swedish and Spanish iron ore.

The Swedish iron and steel industry. Sweden is endowed with one of the world's largest reserves of high-grade iron ore containing about 1½ billion tons of iron (see

[13] The Saar was a German state prior to World War I. After the war it was governed by a commission of the League of Nations, and France was given the right to mine all coal in the Saar for 15 years as compensation for German damage to French mines during the war. Following a plebiscite in 1935, the Saar returned to Germany. In 1945 France occupied the Saar, and in 1947 the Saarlanders voted for economic union with France. On January 1, 1951, the Saar achieved *de facto* political autonomy, a status that may be changed by future events.



Notice how the black areas bring out the major manufacturing areas in Britain, Low Countries, and Ruhr, Lorraine, Alsace, Po Valley, Barcelona, central Germany, Silesia, central Sweden. Kiruna in north Sweden also shows up since mining is included. Compare with Figures 34 and 274. ***U. S. Department of Agriculture***

Table 20:2). The largest deposits are located in the Kiruna-Gällivare district north of the Arctic Circle and not far from the head of the Gulf of Bothnia. The ores of this district are very rich, exceeding 65% in iron content, but most of these ores are phosphoric and require basic steel-making processes. Large-scale production of these ores began in 1903 following the completion of an electric railway that connects the mines with the Swedish

port of Lulea on the Gulf of Bothnia, which is closed by ice in winter, and with the ice-free Norwegian port of Narvik on the Atlantic. Sweden exports about 15 million tons of iron ore a year, chiefly to West Germany and Great Britain.

In central Sweden are the famous Dannemora and Grangesberg mines that have been operated for eight centuries. The ores of this district are among the world's purest iron ores, with a phosphorus content of only 0.001% to 0.02%, but unfortunately reserves amount to less than 50 million tons. These ores are used chiefly in Sweden in the manufacture of products that are sold abroad on a quality and prestige basis, such as hardware, machinery, and electrical apparatus, and also semifinished steel needed to make watch springs, razor blades, cutlery, tools, ball bearings, and other high-grade products.

Limitations of fuel and market affect the character of the Swedish iron and steel industry. Sweden must import more than 90% of her coal supply. She has a population of only 7 million and her domestic market is small. Consequently, Sweden exports more than 90% of all iron ore that comes from her mines, and her annual steel output amounts to less than 2 million long tons. With nearly 60% of her land area in forest, Sweden continues to use charcoal in the manufacture of high-quality pig iron and steel. Sweden ranks seventh among all nations in total water-power development (see Table 19:3), and electricity is used in the production of 20% of her pig iron and 40% of her ingot steel.[14]

Sweden imports heavy steel products, such as structural shapes, rails, and tin plate. Although the total weight of imports exceeds the weight of exports in the ratio of 3 to 1, exports exceed imports in value. Sweden specializes in quality steel.

Spain, Italy, Poland, and Czechoslovakia. In northern Spain near the port of Bilbao are iron mines that yield about 2½ million tons of high-grade ore a year, most of which is exported to the major steel-making nations of western Europe. At Bilbao there is a small steel-making industry. Like Duluth, Bilbao obtains its coal and coke cheaply by water transportation. Vessels leave Bilbao laden with iron ore for Great Britain, and they gladly carry coal and coke at low rates in lieu of ballast on the return trip.

Italy has made much industrial progress through the intensive use of hydroelectric power, but the development of a large iron and steel industry has been handicapped by a notorious deficiency in coal and by very limited reserves of high-grade iron ore. Indeed, the iron mines of Aosta and the islands of Elba and Sardinia yield less than a million tons of ore a year. Although steel of high quality is made in electric furnaces, such as those at Terni along the Nera River in the Apennines, most of the nation's steel is produced in Genoa and Milan in open-hearth furnaces, which are vitally dependent upon large imports of coal, coke, and iron and steel scrap. Italian iron and steel plants have received much government aid. Steel production amounts to about 3½ million long tons annually.

Poland and Czechoslovakia have steel-making industries based upon large deposits of coal, meager deposits of iron ore and imports from Sweden. Both use coking coal from the Teschen field, which was divided between them after World War I. The largest steel plant is the famous Skoda works near Pilsen, Czechoslovakia. The two countries are now under Soviet domination, and they are jointly developing the steel-making district that lies between Ostrava, Czechoslovakia, and Katowice, Poland.

The Schuman Plan. With the single exception of the Soviet Union, no nation in Europe is self-sufficient in both coal and iron ore, the basic resources for steel making. The significance of this simple geographical fact

[14] See Gunnar Löwegren, *Swedish Iron and Steel: A Historical Survey*. Svenska Handelsbanken, Stockholm, 1948, and "Present-day Problems of the Swedish Iron and Steel Industry," *Index*, June 1951, pp. 57–66.

has finally been recognized by the statesmen of six western European countries—France, West Germany, Belgium, Luxembourg, the Netherlands, and Italy. In 1952 these nations formally ratified the Schuman Plan, which provides for the pooling of their steel-making resources and the creation of a common market for their coal, coke, iron ore, and steel. It is hoped that the plan will become fully effective by 1957.

Under the Schuman Plan, trade between the six nations in coal, coke, iron ore, and steel will be free of tariffs. The plan prohibits production subsidies, export and import controls, and differential freight rates favoring exports. Trusts and cartels are forbidden, together with their devices for restricting production, raising prices, and dividing markets. Labor is free to move from one country to another without passports. High-cost coal mines in Belgium and France will be gradually closed down and their owners compensated from a common fund. Many mines and steel mills will be modernized.

A nine-man High Authority administers this ambitious plan. It has the power to issue bonds, borrow money, and receive aid. It may fix maximum and minimum prices. It may purchase whatever coal and iron ore may be needed from nonmember countries. It will surely encounter difficult problems, such as the elimination of high-cost producers, the desire of France and West Germany to control the Saar, and British and Swedish apathy to the Schuman Plan.

If the plan succeeds, free western Europe will be liberated from much of its ugly past. Economic nationalism will be on the wane. Monopoly will yield to competition. Scarcity may give way to an economy of abundance, western Europe may again support itself, and the standard of consumption may rise. The Schuman Plan brings great hope to 160 millions of free Europeans now living in an era of anxiety.[15]

6. THE SOVIET STEEL INDUSTRY

Rapid development. The expansion of the Russian steel industry is a notable material achievement. In 1928 production was about at the 1913 level of 4.5 million tons of steel. This grew to 18.5 million tons by 1939 and, after the decline during World War II, to 37 million tons in 1953, placing the Soviet Union second to the United States in steel production. Like the United States and in contrast to the countries of western Europe, the Soviet Union finds its major resources and markets within its own borders. Soviet rulers rightfully regarded a large steel industry as necessary to the military strength and general industrial development of their country. So they pushed its expansion, along with other heavy industry, at a terrific cost in toil, blood, and privation, and countless Russian rubles.[16]

This task was made more difficult by fundamental geographic conditions. In the vast Soviet Union long rail hauls are often necessary to assemble raw materials, while the important Moscow and Leningrad industrial areas are far from major steel-producing centers. This is in direct contrast to the United States and western Europe where concentrated market areas and producing districts more nearly coincide and are often served by cheap water transportation.

The southern district. Since the late nineteenth century, Russia's leading steel area has been the southeastern Ukraine, near the shores of the Black and Azov seas. This is the most highly developed agricultural area with a major resource base and, in 1950, still produced an estimated 50% of the pig iron and 40% of the nation's steel.[17] Here again the resource locations form a rough triangle. On the east, north of the Sea of Azov, is the Donets

[15] See J. A. Coker, "Steel and the Schuman Plan," *Economic Geography,* October 1952, pp. 283–294.

[16] See John Scott, *Behind the Urals,* Houghton Mifflin Co., Boston, Mass., 1942, and Robert J. Holloway, *The Development of the Russian Iron and Steel Industry,* Business Research Series No. 6, Stanford University, Stanford, Calif., 1952.

[17] Factual data on the U. S. S. R. from Demitri Shimkin, *Minerals, A Key to Soviet Power,* Harvard University Press, Cambridge, Mass., 1953, Chapter III, "Ferrous Metals"; Chapter VI, "Coal and Lignite."

Basin (Donbas), Russia's leading coal field, but the coking coal is high in ash and sulfur content by American standards. About 250 miles to the west and beyond the Dnieper River lie the ore fields of Krivoï Rog with a reserve of 1.5 billion tons averaging about 60% metal content (1938). One of the world's great deposits of manganese lies 50 miles away. The southern apex of the triangle is the Kerch ore field in the eastern Crimea, larger in amount than Krivoï Rog although lower in grade and difficult to smelt.

As is to be expected, coal moves to steel plants at Krivoï Rog and ore is returned to centers like Stalino on the Donets coal field—similar to the Ruhr-Lorraine exchange. Between the coal and iron deposits, other plants are located near the electric-power supply from the huge Dnieperstroy dam. Finally, large plants at Mariupol and Taganrog, on the north shore of the Azov Sea, are located between Kerch ore and Donets coal, in a situation similar to our lake-shore centers. Metal-fabricating and machine industries have developed in the Ukraine, especially in the Donbas. However, much steel must be shipped out, even to the distant industrial centers around Moscow and Leningrad.

Steel centers in the Urals and western Siberia. The Ural district, with substantial deposits of high-grade iron ore, alloy, and many other minerals, was Russia's leading iron-producing area prior to the rise of the Ukraine. Its interior location led both czarist and Soviet planners to regard the development of modern, heavy industry in the Urals as a strategic and economic necessity. The successful realization of such plans proved vital to the military survival of the Soviet regime when the Germans overran the Ukraine during World War II.

Nizhni-Tagil in the northern and Magnitogorsk in the southern Urals, each with a capacity in excess of 2 million tons of steel, are the largest of at least five modern plants. Some of these are at old iron-producing locations, but Magnitogorsk is entirely new. In 1929 its site was an uninhabited steppe, by 1932 the first pig iron was produced, and in 1943 blast furnace No. 6 started operations. Magnitogorsk was developed as a fully integrated plant and depends on the nearby ore of Magnitnaya Mountain. The reserve (419 million tons, 1938) is small by Western standards, but the discovery of a large new deposit east of Magnitogorsk was announced in 1945.

Fuel has been a major problem, since Ural coals are limited in quantity and generally non-coking in character. The original supply for Magnitogorsk came from the Kuznetsk Basin (Kuzbas), a large deposit 1400 miles by rail to the east. A new, integrated steel plant at Stalinsk in the Kuzbas smelted ore from the Urals, and the Magnitogorsk-Kuznetsk Combine thus depended on the world's longest coal-ore exchange by rail shipment. This dependence has been lessened by the development of Karaganda, 600 miles southeast of Magnitogorsk, as an important coal source for the Urals and by the opening of iron mines nearer to the Kuznetsk Basin.

Despite these difficulties, an estimated one third of Soviet iron and steel is produced in the Ural district with an additional 10% in western Siberia, chiefly the Kuzbas. The related metal-fabricating and chemical industries have made the Urals into a major industrial area with lesser developments in the growing cities of Siberia (see Fig. 298).

Steel plants in other parts of the U. S. S. R. The above location of the industry resulted from decisions made during the first two five-year plans. Soviet policy at that time was to build a few large-scale, integrated plants and achieve low *operating* costs even at the expense of high *transport* costs on raw materials and finished products. This placed an increasing strain on the rail system which sometimes carried coal and ore at a loss. In 1938 a new policy was announced which called for a "more rational" location of industry in relation to markets and raw materials.[18]

[18] This change in policy was accompanied by the usual vituperative accusations with which Soviet policy makers accommodate themselves to the realities of economic geography. In the earlier period,

More emphasis has therefore been placed on new plants outside the major districts, while reconstruction and expansion continue in the Ukraine and the Urals. Despite some local production, Moscow and Leningrad have long been "steel-deficit" centers. To reduce this, a large, integrated plant is being built at Cherepovets, about 250 miles southeast of Leningrad. Presumably the plant will draw ore from the Kola Peninsula, some 500 miles to the north, and coal from the Pechora Basin even farther to the northeast. Smaller plants to use local raw materials and supply regional markets are known to be under construction or operating at Rustavi in Trans-Caucasia, near Karaganda in Kazakhstan, and near Tashkent in Central Asia. Other plants are now in operation at Irkutsk near Lake Baikal, at Khabarovsk and Komsomolsk in the Amur Valley, and at Vladivostok along the Pacific.

A comparison of the iron and steel industry of the Soviet Union with that of the United States in terms of present location, future changes, and general prospects raises many interesting problems.

7. IRON AND STEEL MANUFACTURING IN THE ORIENT

The Japanese iron and steel industry. In eastern Asia the industry has depended on limited resources, especially iron ore, in contrast to those of the major industrial nations already discussed. Its development has been beset by problems; characterized by subsidy, tariff protection, and outright government operation; and often directed toward military ends. Japan is a good example.

Japanese steel production, largely controlled by the government, increased from 240,000 tons in 1913 to a modest 2.3 million tons by 1930. Then the preparations for war and the war itself stimulated an increase to a peak of 7.8 million tons in 1943, at a time when the industry had an annual capacity of nearly 12 million tons. Domestic raw materials were (and remain) completely inadequate. Japan is dependent on imported coking coal to mix with the inferior coals from the fields in central Hokkaido and northern Kyushu. Ore is produced in two localities, one in Hokkaido, the other in northern Honshu. But ore production reached only 2 million tons (including iron-bearing sands) even under the extreme wartime demands of 1944.

Imported materials have therefore been of major importance. In 1935–39 Japan imported 90% of her ore supply, chiefly from Malaya, the Philippines, and China. About a third of her pig iron came from India, Manchuria, and Korea. North China supplied about a third of the coking coal, and the United States, about half the scrap. Most of the ferro-alloys were also imported.

Consequently, Japan's industry is even more coastal in its location than Great Britain's. In 1901 the government built the first modern plant at the port of Yawata in northern Kyushu. Nearby coal, easy import of raw materials from the Asiatic mainland, and nearness to Japan's chief urban centers have made Yawata a major center of heavy industry with about one fifth of Japan's steel capacity. Two smaller plants are located on tidewater near the ore deposits in the north—at Kamaishi in Honshu and Muroran in Hokkaido. However, over half of Japan's steel capacity is concentrated near the major port-cities of south-central Honshu, especially in the Hirohata-Kobe-Osaka and the Tokyo-Yokohama areas. Large, integrated, waterfront plants are found in both areas. Since these two are Japan's most important industrial districts, their

those who had pointed to the problems of transport costs and distant markets had been stigmatized as slavish adherents to bourgeois economic principles. After the change in policy, those who had advocated large-scale plants found themselves accused of "Gigantomania," a sin perpetrated by enemies of the state, and a Soviet economist could point critically to the fact that it required six times as much transportation (ton-kilometers of rail freight) to produce a ton of pig iron in the Magnitogorsk-Kuznetsk Combine as it did in the Ukraine. See M. G. Clark, "Some Economic Problems of the Soviet Iron and Steel Industry," unpublished Ph.D. dissertation, Department of Economics, Harvard University, 1950, Chapters 7 and 13.

steel plants are close to market, supplies of scrap, and labor. Imported materials can be delivered as cheaply as to other parts of Japan, and hydroelectric developments in central Honshu are a nearby power source. In these areas there are many smaller steel plants, without blast furnaces, often using electric power to smelt steel from pig iron and scrap, both domestic and imported.

By 1953 Japan's steel production had nearly regained its wartime peak (see Table 21:4). The industry continues to import the major portion of its materials although now shut off from supplies in China and North Korea. Consequently, the United States has become a more important source of Japan's supply. Both the location and the character of Japan's steel industry continue to reflect the fundamental conditions affecting it.

China and Manchuria. China proper had no steel industry prior to World War II. Although the country is rich in coal resources, especially in the north and northwest, the iron deposits are scattered, and by Western standards limited in amount. Hundreds of primitive foundries manufactured simple articles for home use, but no modern blast furnace had a successful period of operation, and only a little steel was produced in small furnaces for the local market at Shanghai. A small, integrated steel plant had operated intermittently at Hankow, but was shut down in the 1920's and dismantled in the 1930's. Another blast furnace built near Peiping did not operate prior to the Japanese invasion of 1937. China was more important as a source of iron ore and coking coal for Japan.

In Manchuria, however, a modern steel industry had been developed at considerable expense by the Japanese, and this became China's most important area for heavy industry. Between 1936 and 1943 Manchurian coal production increased from 13 to 30 million tons; iron ore from 2 to 5.3 millions; pig iron from 0.6 to 1.7 millions; and ingot steel from 137,000 to 837,000 metric tons. All the steel and three fourths of the pig iron was produced at the Showa Steel Works at Anshan, which also had rolling mills. Limestone and ore were near the plant. But the ore averaged only 35% iron and had a high silica content, so the Japanese spent much time and money developing methods for processing it. Steam coal at Fushun and coking coal at Penhsihu, where there was another blast furnace plant, were within 100 miles of Anshan. Although iron and steel were exported to Japan, metal-fabricating and machine industries developed in the city of Mukden 60 miles to the north.[19] Much of this industrial complex was damaged or removed by the Russians in 1945.

The Chinese Communists now claim that the industries have been rebuilt with Russian equipment, capacity has expanded, and production is above previous peaks. Such claims may be exaggerated,[20] but is is safe to assume that 1954 production may approximate prewar levels.

More important than the actual level of present production is the fact that Manchuria, together with adjacent northern China and North Korea, has a better raw-material base for heavy industry than does Japan.

Iron and steel manufacture in India. The Republic of India is well endowed with nearly all the resources for steel making. In terms of iron content, Indian ore reserves are the largest in the world (see Table 20:2). Total coal reserves are estimated at 20 to 25 billion tons. With the exception of nickel and molybdenum, India is self-sufficient in the ferro-alloys. In one respect India is poor: known coking-coal reserves amount to less than 1 billion tons, and these will be exhausted by 1985 at the present rate of consumption.[21]

At Jamshedpur the Tata Iron & Steel Co. operates an iron and steel plant which in prewar years was the largest in the British Em-

[19] See Allan Rodgers, "The Manchurian Iron and Steel Industry and its Resource Base," *The Geographical Review,* January 1948, pp. 41–54.

[20] See *The New York Times Magazine,* August 29, 1954, p. 34; and Sept. 5, 1954, p. 4.

[21] See John E. Brush, "The Iron and Steel Industry of India," *The Geographical Review,* January 1952, pp. 37–55.

pire. It began operations in 1911 and was developed entirely by Indian capital and initiative. Within a radius of 110 miles are the resources for steel making: coal in the Damodar River Basin, the iron ores of Mayurbhanj and Singhbhum, the limestone of Gangpur, and local maganese and tungsten. About 150 miles to the east is Calcutta, the great seaport and India's largest market for finished steel products.

To the north of Jamshedpur are lesser plants in the Damodar Basin in the vicinity of Asanol. With cheap labor and easy access to fuel and raw materials, the Jamshedpur-Asanol district makes some of the cheapest pig iron in the world. For years prior to World War II India was the leading exporter of pig iron, but since 1945 nearly all pig iron has been converted into steel.

By standards of the Western World, the Indian iron and steel industry is small. In 1953 India produced only 1½ million tons of ingot steel. India now exports small amounts of iron ore and pig iron but remains an importer of steel. The nation is predominantly agricultural, and the lack of a big industrial market goes far to explain the limited development of iron and steel manufacturing.

STEEL CENTERS IN THE SOUTHERN HEMISPHERE

Developments in Australia. Australia has coal and iron but only 11½ million people. Here, as elsewhere in the Southern Hemisphere, the steel industry suffers the handicap of a small and limited market. The modern steel industry dates from 1915 when the Broken Hill Proprietary Co. built an integrated plant at Newcastle. Since 1921 the government has levied high import duties on iron and steel, and between 1921 and 1953 the nation's output of ingot steel increased from 280,000 to 1,830,000 long tons. Iron and steel plants at Newcastle, Port Kembla, and Lithgow, along the coast of New South Wales, utilize high-grade coal from nearby mines, limestone from nearby quarries, and rich iron ore that is transported cheaply by ocean vessels from the Iron Knob district near the port of Whyalla on Spencer Gulf in South Australia. Iron-ore deposits are also being developed on little Koolan Island in Yampei Sound along the northwest coast of western Australia. The ease of assembling fuel and raw materials makes the cost of steel unusually low.[22]

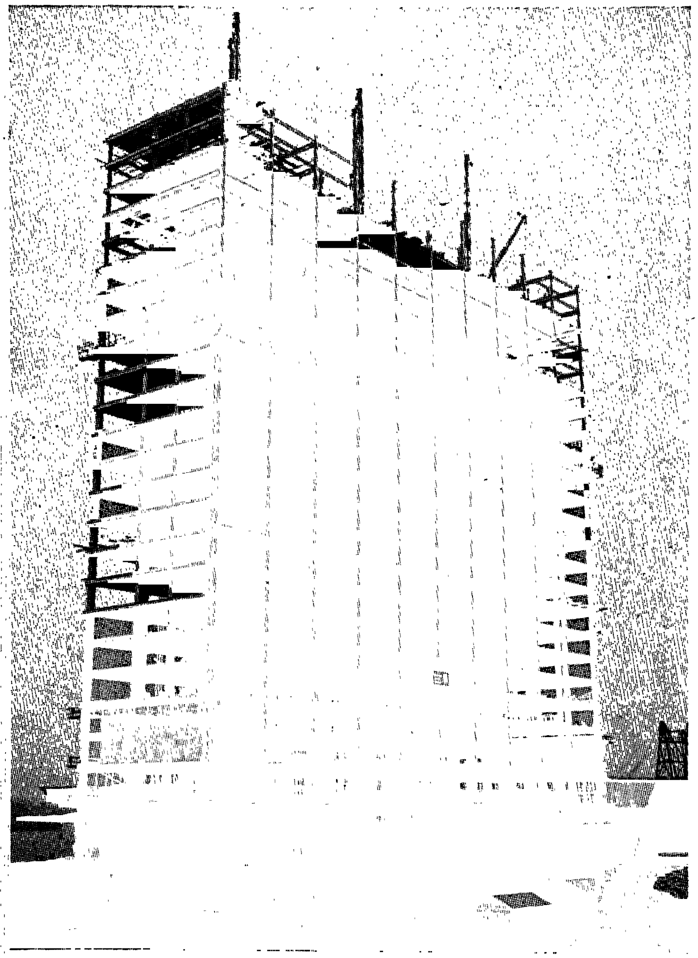
Australia now supplies itself with steel and exports a little to New Zealand. Although Australia is well endowed with coal, its total iron ore reserves are not large, and its domestic market is indeed limited. In view of these limitations and Australia's remote location in reference to large foreign industrial markets, no great expansion of Australian iron and steel production can be anticipated.

The Union of South Africa. Africa lags far behind the other continents in the development of manufacturing, and the Union of South Africa is the only producer of iron and steel. Although well supplied with raw materials and fuel, South Africa manufactures less than 1 million long tons of ingot steel a year, because the market is small. Steel-making plants are located at Pretoria and Vereeniging in the Transvaal and at Newcastle, Natal. The government is committed to nationalization of the iron and steel industry.

Latin America. With 7% of the world's population, Latin America has over 20% of the world's known iron ore reserves and only 1% of the coal (see Tables 17:4 and 20:2). Although Mexico, Brazil, Argentina, and Chile have developed manufacturing with the aid of tariffs, no Latin American country has more than an infant iron and steel industry. The combined capacity of all Latin American steel-making plants is less than 2½ million short tons, or less than 1% of the world's total.

Brazil accounts for one half of Latin America's ingot-steel production. The chief

[22] See "World's Cheapest Steel," *Fortune,* November 1950, pp. 83–88 ff.



Skeleton of 24 of the 39 stories of U. N. Secretariat building. It is fitting that the capitol of the world has a frame of steel. *U. N. Photo*

Brazilian steel plant is located at Volta Redonda between Rio de Janeiro and São Paulo. It obtains iron ore, limestone, and manganese by rail from the Lafayette district of Minas Gerais some 250 miles to the north. It uses both imported and domestic coals, since Brazilian coal reserves are small and of inferior quality. The domestic coal comes from mines at Tubarão, Santa Catarina. To reach the steel plant, Tubarão coal moves 40 miles by rail to the seacoast, thence by vessel to Angra dos Reis or Rio de Janeiro, and finally by rail to Volta Redonda, a combination rail-water-and-rail haul of about 650 miles. While Volta Redonda is of local importance and is sometimes considered a symbol of industrial maturity, its existence depends upon a protective tariff.[23]

Mexico and Chile, like Brazil, have tariff-protected iron and steel industries. The largest Mexican plants are at Monterrey in the mountains of Nuevo Leon and at Monclova in the adjacent state of Coahuila. These plants are supplied with coal from the Sabinas and Lampazos fields of Coahuila and with iron ore from the Cerro del Mercado mines of Durango. Both plants are more than 600 miles by rail from the main domestic market, which has developed around Mexico City and other industrial centers of the Central Plateau.

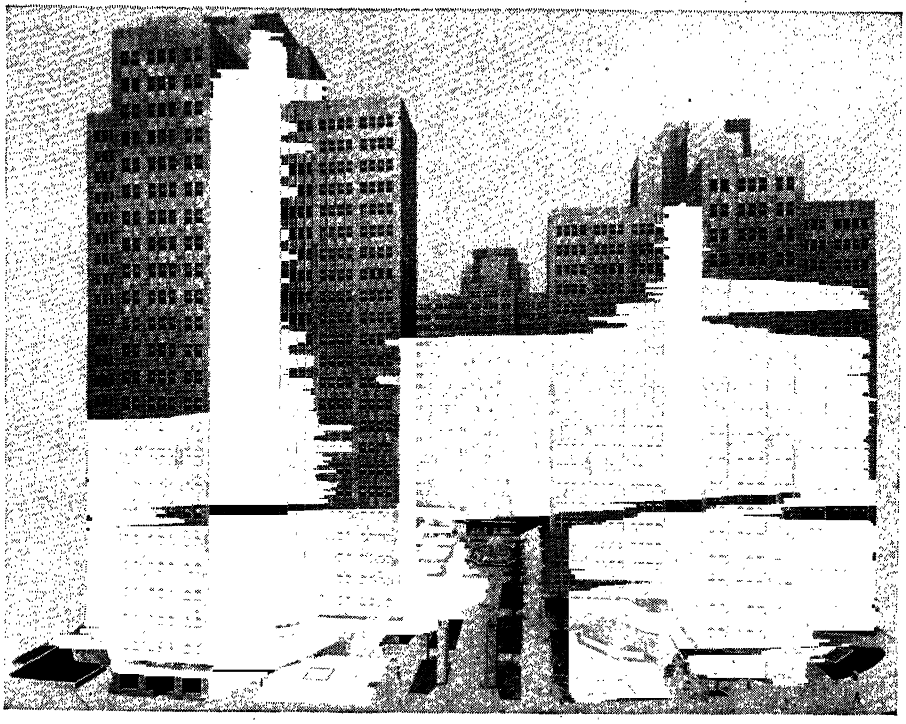
Chile has a new $100 million plant built by the government at Huachipato, near Concepción on San Vicente Bay. Its tidewater location facilitates the assembly of coal from nearby mines at Lota and Schwager, iron ore from El Tofo about 500 miles to the north, and limestone from the Madre de Dios Islands some 900 miles to the south. The plant is well located to serve the Chilean market.

Unless the iron and steel industry of a nation is blessed with easy access to abundant and suitable iron and coal and to a large and growing industrial market, its development is seriously handicapped. The experience of Latin America, Canada, South Africa, Australia, and Oriental nations illustrates this basic truism of modern iron and steel production.

9. WORLD TRADE IN IRON AND STEEL

Movements of iron ore. Since iron ore is a heavy, bulky, and low-valued commodity, it cannot stand high transportation costs. It can move nearly halfway around the world cheaply in ocean vessels, but it seldom moves more than 300 miles overland. Hence, water transportation plays a big role in both domestic and international trade. Without the cheap transportation afforded by the North Ameri-

[23] See Robert G. Long, "Volta Redonda: Symbol of Maturity in Industrial Progress of Brazil," *Economic Geography,* April 1948, pp. 149–154.



Gateway Center buildings, Pittsburgh. Outside 640,000 square feet of stainless steel, 400 tons, 22 gauge, outer cover of insulated panels hung onto standard steel skeleton. Very light, no paint, no rust. *American Iron and Steel Institute*

can Great Lakes, by the rivers and canals of western Europe, and by the great ocean highway, the assembly of most of the world's iron ore would be stymied.

The big markets for iron ore are Germany, Belgium-Luxembourg, Great Britain, Japan, and the United States. Nearly 20 different countries are engaged in the export of iron ore, but France and Sweden have long been the leading exporters, chiefly because they are near the ore-needy countries of western Europe and because they have such large reserves and a surplus for export located near water transport. In 1953 the United States produced 133½ million tons of iron ore but also imported 12½ million tons, chiefly from Chile, Sweden, Venezuela, and Canada.[24]

Movement of iron and steel manufactures. Iron and steel manufactures have much greater value than iron ore and can stand much higher transportation costs. They travel much farther overland, and they are shipped overseas to some of the most remote parts of the world. From the great steel-making plants of western Europe and eastern North America have come vast quantities of steel rails, bridges, girders, machinery, and countless consumers' goods for use by the people of every land. Prior to World War II, there was a large trade between the nations of western Europe in finished and semifinished steel products, and the Schuman Plan aims to revive and increase this trade.

An increasing number of nations are promoting iron and steel manufacturing by protective tariffs, import quotas, production subsidies, and outright government ownership. Even the gigantic U. S. steel industry is protected by tariff! As a result of the growth of trade barriers, European and American exporters have seen good foreign markets dwindle and disappear. Today the world is sharply divided into communist and free nations, with little trade between them. As never before, the exporter is confronted with a maze of obstacles. No longer is there one great world market for exportable goods. Who can foretell the future?

[24] American Iron and Steel Institute, *Steel Facts,* April 1954, p. 4.

22· The Copper Industry

1. THE USEFULNESS OF COPPER

Copper at the dawn of civilization. More than 7000 years before modern man utilized copper to usher in the present era of electricity, Neolithic man discovered that the red metal had useful qualities which were far superior to those of wood, bone, and stone for making tools, weapons, ornaments, and various utensils. Copper is malleable, and man found that lumps of native copper, obtained from surface outcrops, could be hardened and brought to a fine edge by hammering. The metal has a low melting point, and the quantity available for use was greatly increased when someone discovered that copper could be easily smelted from its ore. Later it was found that copper fuses readily with tin to make bronze and with zinc to make brass.

Both bronze and brass are far more durable than copper, and bronze holds a much sharper cutting edge. Bronze proved useful in so many ways that primitive man was able to emerge from the Stone Age into an advanced stage of civilization that has been aptly called the Bronze Age. While nobody knows when man first used copper, archeological excavations have uncovered copper objects made prior to 4000 B.C. in Mesopotamia and Egypt, and we know that bronze was produced in the Near East about 2500 B.C. It is generally believed that the stone-copper-bronze cycle occurred in Europe about 2000 B.C. and about the same time in China and India, but it did not evolve among the Aztecs of Mexico and the Incas of Peru until about the beginning of the Christian era.

About 2000 B.C. Hissarlik was a flourishing bronze-making center on the shores of the Dardanelles. From Hissarlik Cretan traders carried swords, spears, hooks, scythes, and other articles of bronze for sale throughout the Mediterranean world.[1] In the early years of the Roman Empire well-organized factories at Capua turned out articles of copper, bronze, and brass, each bearing the name of the producer. Skilled metallurgists melted the copper, carefully mixing it with tin or zinc, while others specialized in forging, carving, polishing, and other tasks. So excellent was the quality of the output that Cato advised his readers to buy bronze buckets, containers for wine, oil, and water, and all other copperware made at Capua.[2] Bronze lamp stands, tables, braziers, tripods, and other metal furniture produced at Capua have been found in the ruins of Pompeii. Ancient artisans were able to cast bronze statues of enormous size. Copper, bronze, and brass were also used at various times for coinage, the "widow's mite" of Biblical fame being made of copper.

---

[1] See L. F. Salzman, "Metals," *Encyclopaedia of the Social Sciences,* The Macmillan Co., New York, Vol. 10, 1933, pp. 364–365, and William Y. Elliott and others, *International Control in the Non-Ferrous Metals,* The Macmillan Co., New York, 1937, pp. 389–390.

[2] See Tenney Frank, *An Economic History of Rome,* The Johns Hopkins Press, Baltimore, 1927, pp. 236–237.

Old Santa Eulalia mining camp near Chihuahua, Mexico. Mexican mines often contain lead, zinc, silver, and copper. Such arid hills may rise anywhere in a million square miles from British Columbia to Mexico City—South America—South Africa—southwestern Asia. *Mexican Embassy, Washington, D. C.*

Copper: the handmaiden of electricity. Although copper is one of the oldest of metals in the service of man, it has "grown up" with the electric dynamo very much as iron and coal grew up with the steam engine and as petroleum achieved its maximum development with the advent of the internal combustion engine. With the exception of silver, copper is the best conductor of electricity known to man; it resists corrosion, it is easily drawn into fine wire, and it is comparatively cheap. Hence, copper became the handmaiden of electricity and has proved indispensable to the generation, transmission, and use of electric power.

It was chiefly the demand arising from the phenomenal growth of the electrical industry, together with modern improvements in mining, smelting, refining, and fabrication of the metal that caused the world's copper production to increase from 173,000 tons in 1880 to 1,100,000 tons in 1913, and to 3,068,000 tons in 1953. In fact, over one half of all copper consumed in the United States each year is associated with the use of electricity. Among the thousands of devices that depend upon the electrical conductivity of copper are the light bulb, vacuum cleaner, mechanical refrigerator, air-conditioning apparatus, telegraph, cable, telephone, radio, television, electric locomotive, railway signal equipment, and the ignition system of every automobile. The spatial significance of the copper wire in modern communication is revealed by the fact that the earth is belted with 30,000 miles of submarine cables and by about 6 million miles of telegraph wire, while the world's 70.3 mil-

lion telephones are linked together by 200 million miles of wire.

Nonelectrical uses. Copper has come to rank second only to iron among the great industrial metals. Of the copper consumed in this country each year, about one tenth is utilized by the automobile industry for nonelectrical purposes, and another tenth is employed by the construction industry for roofing material, water pipes, and other uses (see Table 22:1).

TABLE 22:1. Use of Copper in the United States in 1950
(percent of total consumption)

	%
Electrical equipment (motors, generators, switchboards)	20
Building (plumbing, flashing, leaders)	10
Automobiles (mainly in radiators)	10
Other rod and wire	9
Light and power	7
Telephone and telegraph	6
Ammunition (cartridge cases and rotating bands)	5
Radio and television	4
Air conditioning	2
Refrigerators	2
Railroads (mainly bearings)	2
Ships (propellers)	2
Others	21
Total	100%

Source: Copper and Brass Research Association, cited in The President's Materials Policy Commission, *Resources for Freedom,* Washington, Vol. 2, 1952, p. 33.

Copper, bronze, and brass are extensively used in shipbuilding and locomotive manufacture. A medium-sized tank requires ½ ton of copper, while as much as 3 tons are used in making a long-distance bomber. Furthermore, copper is cast into bearings, bushings, lubricators, valves, and fittings; it is alloyed with iron and nickel in the production of stainless steel, with nickel to make Monel metal, and with aluminum to make duralumin; and it enters into the manufacture of steam radiators, clocks, watches, locks, and many other things.

Copper also continues to perform its ancient monetary function. It is used as an alloy in making silver coins. The lowly and ubiquitous penny is 95% copper, and every year the United States Mint buys 2000 to 7000 tons of the red metal to supply the nation with pennies.

2. THE OCCURRENCE AND MINING OF COPPER

Nature and occurrence of copper. Copper is of igneous origin, and while it is occasionally found in a metallic or "native" state, it usually occurs in chemical combination with other elements in the form of an ore, such as a sulfide, oxide, chloride, or carbonate. Frequently other metals, such as gold, silver, nickel, tin, lead, and zinc, are found in the same body of ore, these valuable by-products being recovered in the process of smelting and refining. Sometimes copper itself is a by-product of mining, as in Canada, where nearly half of the annual copper output is a by-product of nickel mining.

Copper ore may be found in rich veins or pockets, or it may be disseminated throughout a great mass of rock or earthy material, called gangue, which must be excavated along with the ore and later separated from it. In contrast with iron ore, which ranges from about 25% to over 60% in metallic content, most copper ore that is mined today contains less than 3% copper. Few ores exceed 6%, while those in the United States now average less than 1%. Indeed, huge bodies of disseminated ores with a metallic content of only 1% to 2%, known as porphyries, may actually contain far more metal than concentrated richer veins, and it may be noted that the huge copper reserves in northern Chile consist of such low-grade porphyry ores.

The shift from selective to mass mining methods. In spite of increased mechanization of mining, the production of copper throughout most of the nineteenth century was impeded by the crude concentrating and smelting methods that made it necessary to restrict mining activity to veins or pockets that would yield rock high in copper content. If any considerable amount of poor ore and waste rock was mixed with good ore, the recovery of copper was too low to yield a profit. There-

fore, it was necessary to practice careful "selective" mining, which involved the tedious separation by hand of pay ore from poor ore and waste rock. This restriction on mining largely explains why the world's output of copper increased slowly from about 18,000 tons in 1800 to only 52,000 tons in 1850, and to 173,000 tons in 1880.

Toward the end of the nineteenth century, technological improvements made it possible to concentrate and smelt ore of lower grade at a profit. No longer was the miner forced to grub painstakingly along the pay streak, watching every crumb of ore. Instead, the miner could extract all mineralized rock and send it to the concentrating mill and smelter, which handled the problem of selection and recovery. With the advent of nonselective, mass-mining methods, production costs were greatly reduced, and today it is possible to utilize nearly all the ore found in veins or pockets and also to exploit such low-grade porphyry ores as those in Utah, Arizona, Nevada, and northern Chile. The increasing use of power-driven machinery has continuously reduced the amount of manual labor required and has enabled man to pursue pay ore deeper and deeper into the bowels of the earth. As in iron mining, both underground workings and open-pit methods are used. The deepest mine in this country is the old Quincy copper mine near Hancock, Mich., where shafts penetrate the earth to a depth of more than 6600 feet, and the largest open-pit copper mine is at Bingham Canyon, Utah, where a mountain 2½ miles long and half a mile high is being blasted and shoveled away.

3. THE TECHNOLOGY AND LOCATION OF MANUFACTURE

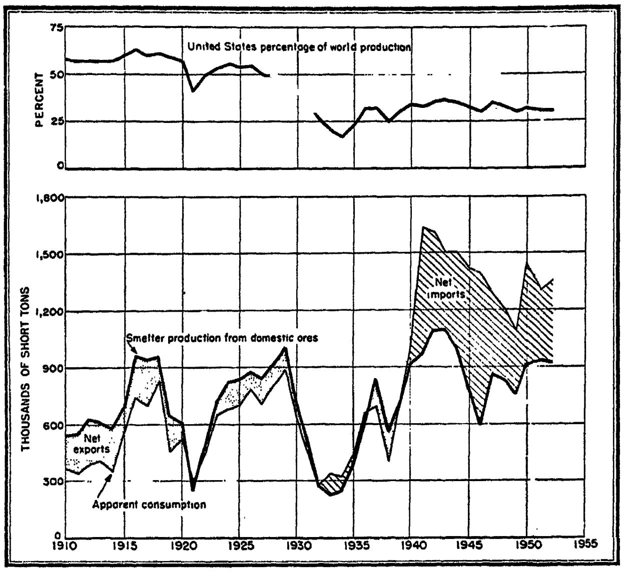
The concentration of copper ore. On its way from mine to market, copper usually moves through the processes of concentration, smelting, converting, refining, and fabrication before it is ready to meet the needs of consumers.[3] The concentrating mill is located near the mine, because the ore is generally mixed with large amounts of heavy, worthless rock, earthy material that can be transported economically only a few miles. This mine mixture is crushed, screened, and sorted mechanically and is then washed by a current of water across oscillating trays that catch and retain the heavier mineralized particles, or concentrates, which are high enough in copper content to be ready for the smelter.

The refuse from the water-concentration process contains much copper, so it is ground into a fine powder and put into a tank containing oil and water, which are agitated to a froth and then allowed to settle. The copper-bearing particles adhere to the oil at the surface, while the refuse settles and is drawn off from the bottom of the tank. The copper concentrate is easily separated from the oil and is dried and sent to the smelter. This froth-flotation process, which was discovered in 1905 and first used in Australia, was one of the great triumphs in the technological advancement of the industry, for it brought about a much more effective recovery of copper and the use of low-grade ore that formerly had no commercial value.[4]

If the ores are sulfides, they may be sent from the concentrating mill to a roasting furnace, which eliminates much of the sulfur and oxidizes many of the impurities prior to smelting. On the other hand, oxide ores are usually treated by leaching. The crushed ore is placed in a large vat, sometimes holding more than 10,000 tons, and a sulfuric-acid solution percolates down through the ore and leaches out the copper in the form of a copper sulfate solution. This is run into electrolytic tanks,

[3] The treatment of copper ores is characterized by a multiplicity of processes that are carefully adapted to the properties of individual ores. See Erich W. Zimmermann, *World Resources and Industries*, rev. ed., Harper & Brothers, New York, 1951, pp. 700–701, and Evan B. Alderfer and Herman E. Michl, *Economics of American Industry*, McGraw-Hill Book Co., New York, 1950, pp. 86–90.

[4] At first the froth-flotation process was satisfactory for the treatment of an ore from which only copper was to be recovered. Later this process was developed into a selective or differential one, which uses various oils or chemicals to recover silver, lead, zinc, and other metals from complex ores.



We do our copper in a big way, but our share declines. Near-constant peaks in boom and war; depression lows, despite tariff protection. Terrible fluctuation for desert towns. ***U. S. Bureau of Mines***

where an electric current, flowing through the solution from insoluble anodes, deposits copper on cathodes. After the cathodes are built up with sufficient copper, they are sent to the smelter to be purified and cast into commercial shapes.

The smelting and converting processes. In the process of smelting, additional impurities are removed either in blast furnaces or reverberatory furnaces. In the copper blast furnace the concentrated ore is mixed with limestone and coke and is treated in about the same way as is iron ore in the production of pig iron. Reverberatory smelting employs a furnace that operates much like the open hearth in steel making, and it has almost entirely displaced the blast furnace, which is not adapted to handle the finely pulverized concentrates produced by the flotation process. Today reverberatory furnaces account for more than 95% of the total smelting capacity of the United States.

The product of the smelter is known as copper matte, which has an average metallic content of 40% to 50% but which may contain 60% or more copper. Since copper concentrates are usually too low in value per unit of bulk to stand the costs of long-distance transportation, smelters are generally located in the mining district near the concentrating mill at some point that has access to limestone and coke.

Closely associated with smelting is the process of converting copper matte into blister copper, which is about 99% pure.[5] As a rule, copper matte is conveyed in the molten state by ladles from the smelting furnace to the converter, which operates like a Bessemer converter in the manufacture of steel. Because of its purity and greater value in proportion to bulk, blister copper can obviously be transported longer distances than 60% copper matte, just as 20% to 40% matte can move farther than copper concentrates or ore.

Refining and fabrication. Blister copper contains minute quantities of the baser metals, such as lead and zinc, which must be removed if the copper is to be used by the electrical industries. It also contains precious gold and silver that are well worth recovering. Hence blister copper is sent to a refinery, where the principle of electrolysis is employed to remove the last impurities and to build up cathode plates of virtually pure copper. These cathodes are then melted in reverberatory furnaces and are cast into various shapes, which are ready for fabrication.

Since high-grade matte and blister copper can be transported economically long distances, copper refineries do not have to be located near the raw material. A seaboard refinery has the obvious advantage of cheap water transportation and is able to obtain its raw material cheaply from a variety of sources. Indeed, most of the world's copper refineries occupy coastal locations in proximity to great markets and abundant supplies of cheap electric power, although some important refineries

[5] The product is called "blister copper," because air bubbles escaping from the cooling metal cause blisters to appear on the surface.

are found at interior points in or near copper-mining areas. About 50% of the refining capacity of the United States is located between New York and Baltimore (see Table 22:2).

Copper is shipped from the refinery in forms that are convenient for manufacture. Thus, copper destined for wire-drawing mills is shipped in wire bars with pointed ends to facilitate the entry of the bars into the first set of rollers. If copper is to be remelted in crucibles to make copper castings or to manufacture brass, bronze, or other alloys, it is shipped from the refinery in deep-notched ingot bars that can be easily broken into small parts that will fit readily into crucibles. Billets up to 6 inches in diameter are shipped to tube mills. Slabs and square cakes of various sizes go to rolling mills, where sheets, strips, bus bars, etc., are the final products, but circular cakes are needed for the manufacture of seamless, cylindrical products, such as tanks and kettles.

TABLE 22:2. Annual Capacity of United States Copper Refineries, 1953
(short tons)

Electrolytic refineries	
Eastern:	
Perth Amboy, N. J.	240,000
Baltimore, Md.	198,000
Barber, N. J.	168,000
Carteret, N. J.	144,000
Laurel Hill, N. Y.	140,000
Western:	
El Paso, Tex.	240,000
Garfield, Utah	192,000
Great Falls, Mont.	150,000
Tacoma, Wash.	120,000
Inspiration, Ariz.	39,000
Total	1,631,000
Lake and fire refineries[a]	
Eastern:	
Hubbell, Mich.	100,000
Carteret, N. J.	56,000
Hancock, Mich.	12,000
Western:	
Hurley, N. Mex.	72,000
El Paso, Tex.	25,000
Total	265,000
Total refining capacity	1,896,000

a The final product of the lake refineries at Hubbell and Hancock, Mich., located near the shore of Lake Michigan, is known in the trade as "lake copper," while that of the fire refineries is known as "fire-refined." Both use furnace methods.

Source: Adapted from American Bureau of Metal Statistics, *Year Book of the American Bureau of Metal Statistics, 1953,* New York, June 1954, p. 21.

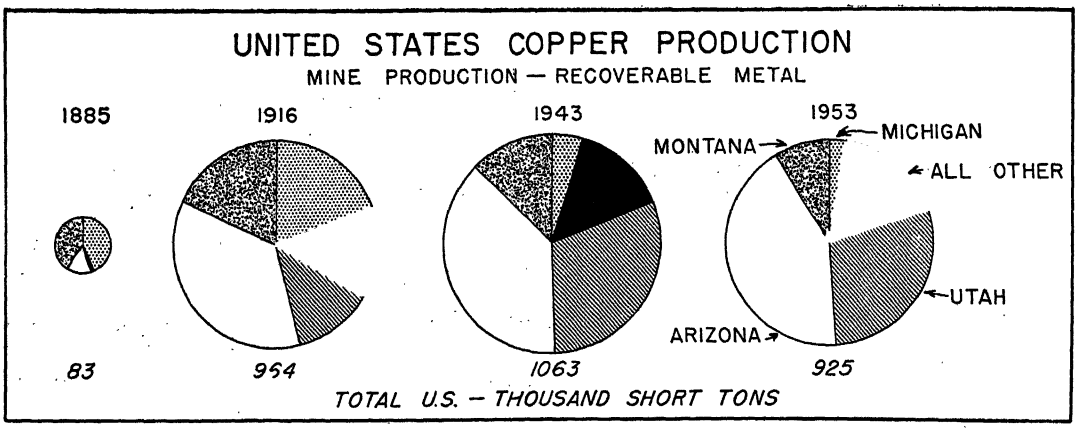
The final step in the manufacture of copper occurs when these various shapes are fabricated by the metal-working establishments. In the United States about 70% of all copper is used in the manufacture of producers' goods, and consequently the copper industry is vitally dependent upon the continued industrial growth of the market and suffers greatly during periods of business depression.

The importance of secondary copper. Since it is cheaper to remelt and refine copper scrap than to dig ore and extract the metal and since copper alloy scrap can be fabricated anew without breaking it down into its component parts, secondary copper has come to be of increasing importance. About half our secondary copper is derived from old scrap gathered from junk piles and other sources throughout the country, the remainder being obtained from new or industrial scrap that was discarded by factories and mills.

About 60% of all copper put into use is eventually recoverable. While the growing supply of scrap and man's increasing ability to use it means greater competition for copper-mining companies, from the viewpoint of conservation it is good that this durable metal can be recovered and used again and again.

4. WESTWARD MIGRATION OF U. S. COPPER PRODUCTION

Growth of U. S. copper production. The development of American copper production during the last hundred years was an integral part of the westward expansion of the nation. As railroads penetrated the West, as new and important deposits were discovered, as the new technology made lower-grade ores available for use, copper production moved westward, and the nation's output greatly increased. As in the exploitation of most of our mineral resources, we began by skimming the "cream" and later turned to recovering the



The copper boom crosses the Rockies. Michigan declines much; Montana declines a half; Arizona and Utah become giants. ***U. S. Bureau of Mines***

thinner but more voluminous "milk," for the expansion of our copper production was based upon the successive development of the unusually high-grade copper of Michigan, the less rich veins of Montana, and the low-grade porphyry ores farther west.

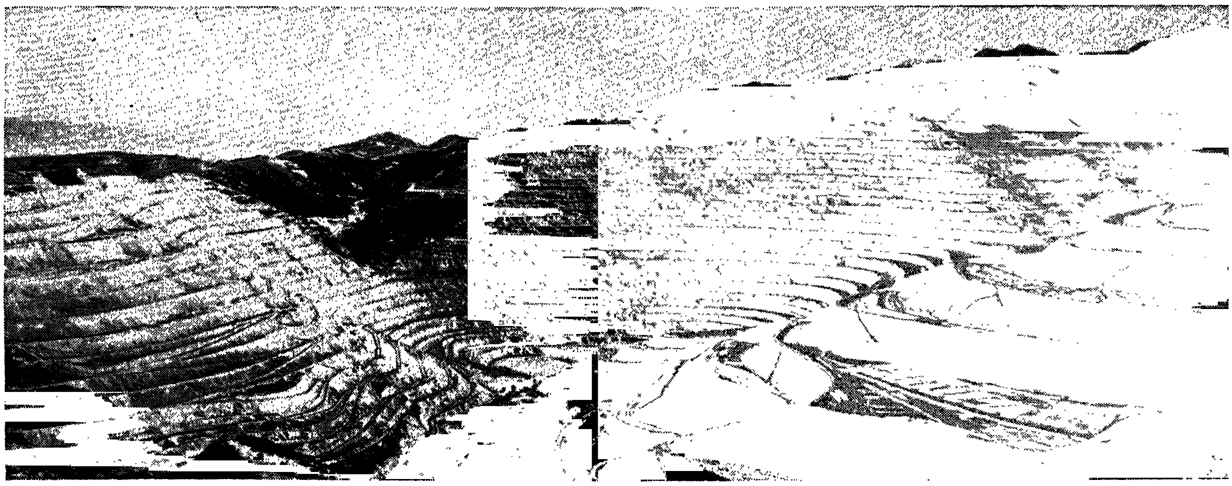
From a minuscule yield of about 750 tons in 1850, or less than 1½% of the world's supply, the nation's smelter output from domestic ores increased to 30,000 tons in 1880, 303,000 tons in 1900, 605,000 tons in 1920, and 925,000 tons in 1953. Since 1883 the United States has been the world's premier producer of copper, and from 1894 to 1928 American mines maintained an almost continuous record of producing more than a half, and at times two thirds, of the world's total output. Since 1928 the continued growth of foreign production has caused a decline in the relative importance of American copper, which now amounts to about one third of the world's supply (see Fig. 384).

The pioneer Michigan copper district. From 1845 to 1887 the Upper Peninsula of Michigan was the leading copper-mining district of the United States, its early development being stimulated by its relative nearness to market, by the cheap transportation afforded by the Great Lakes, and by the exceptional purity of its copper.

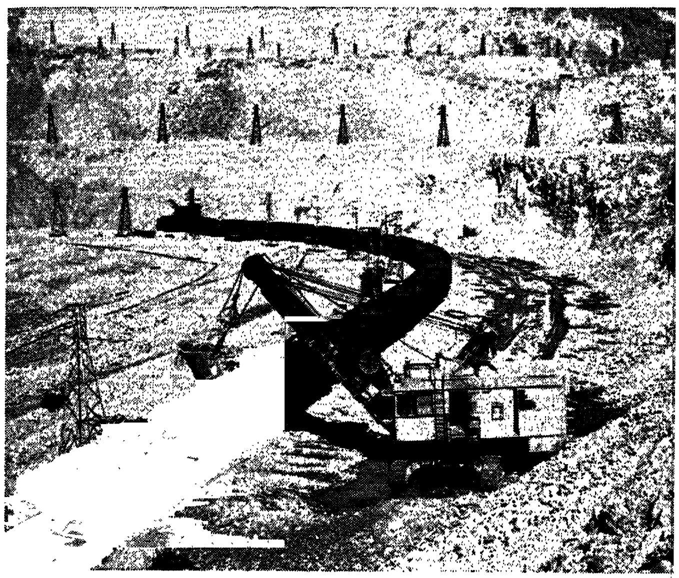
In the old rocks of this glaciated district are large copper deposits, unusual in that some of them consist of native or pure metallic copper. Unfortunately, many of the masses are often too large to be taken out whole. Thus one single chunk, weighing 540 tons, had to be chiseled by hand into smaller pieces. However, the use of diamond drills and other modern devices has eliminated much of this manual labor, and shafts have been sunk deep into zones where copper occurs in smaller masses, some mines being more than a mile deep. The ore of this district is concentrated, smelted, and fire-refined in furnaces at Hubbell and Hancock, which obtain their coal and coke cheaply via the Great Lakes.

While from 1845 to 1880 Michigan produced 75% to 85% of the nation's copper, today its share is only 2½%, and its output is exceeded by that of five western states (see Fig. 386). Occasionally, the high prices of boom times stimulate output, but the old mines of Michigan are confronted with diminishing productivity, which is the fate of all mining industries.

The Butte copper district. In 1882 a huge deposit of copper was struck in a hill at Butte, Montana, as the result of a search for silver, and five years later Montana became the leading copper-producing state. At the present time ore is hoisted from the mines at Butte and is shipped 26 miles by rail to Anaconda, where it is concentrated, smelted, and converted into blister copper. (Butte does not have the huge amount of water needed for concentration and smelting.) From Anaconda



(Above) **Bingham Canyon Mine, near Salt Lake City. Largest producing copper mine in the world: 2000 feet from top to bottom ore goes deep. Banks at right are 60 to 70 feet high. A long life ahead.** ***(Right)*** **An electric shovel at work in Bingham Canyon Mine. Ten tons each scoop: 19 lbs. of copper per ton, 15 lbs. secured. Large-scale, scientific technical triumph. Consider depression price cut. Such shovels lift most of the world's iron and copper ore.** ***Kennecott Copper Corp.***



the blister copper moves to an electrolytic refinery at Great Falls, where cheap hydroelectric power is available.

Today the great hill at Butte is pierced by more than 100 shafts, some of them 4100 feet deep. About 5500 miners work in the 2700 miles of underground passages.

A system of block caving is now being used to mine 130 million tons of low-grade ore deep in the earth, some of it below old abandoned mines. The ore is undercut with a series of tunnels. When it is honeycombed with holes, it crumbles like sawdust and falls by its own weight into cars to be hauled to the nearest shaft. By this method a great mass of ore can be handled with fewer men and less equipment. Since the beginning of mining operations, the Butte district has yielded nearly 7 million tons of copper, or about 19% of the total output of the United States to date.

The prolific porphyry ores of Arizona, Utah, and Nevada. Copper mining in Arizona began in the early 1870's with the development of the Morenci district, which was soon followed by other discoveries. Mining, therefore, was at first confined to the richest deposits, and it was not until 1907 that Arizona turned to nonselective mass mining of low-grade porphyry ores. In 1907 supremacy in output passed from Montana to Arizona, which, with a single exception in 1909, has retained leadership to the present day.

Most porphyries in Arizona are easily worked with power shovels, but others, because of their depth, require the use of shaft mining and block-caving methods. Arizona mines have proved to be the most prolific in our copper history, yielding about 13 million tons of copper or about one third of the nation's output to date. Such mining towns as

Globe, Bisbee, Jerome, Ajo, and Morenci are almost entirely dependent on the red metal, which is more valuable per capita to the sparse population of Arizona than is wheat in North Dakota or coal in Pennsylvania. When the copper is gone, the towns will perish as other towns have done.

The United States' pioneer porphyry mine and our greatest copper mining district of today is at Bingham Canyon, Utah, a few miles south of Great Salt Lake. Although the ores of this district average only 1% in metallic content, they contain about 7 million tons of copper and comprise the largest known copper reserve in North America. Open-pit mining operations began in 1907, and today giant electric shovels continue to bite into the mountain of copper, electrified trains hauling the ore to concentrating mills nearby. At Garfield the concentrates are roasted and smelted, and the copper moves through the converting and refining processes.

TABLE 22:3. Summary of World's Copper Reserves, 1946

Country	Metal content in short tons	% of world total
United States	29,200,000	26.4
Chile	25,900,000	23.4
Northern Rhodesia	21,100,000	19.0
U. S. S. R.	9,000,000	8.1
Canada	7,700,000	7.0
Belgian Congo	7,400,000	6.7
Peru	2,500,000	2.2
Spain	1,200,000	1.1
Japan	1,000,000	.9
All others	5,800,000	5.2
Total	110,800,000	100.0

Source: Computed from U. S. Federal Trade Commission, *Report on the Copper Industry,* Washington, 1947, pp. 34–36. For other estimates, see Percy E. Barbour, "World Copper Reserves," *Engineering and Mining Journal,* October 1934, p. 149, and William P. Shea, "Foreign Ore Reserves of Copper, Lead and Zinc," *Engineering and Mining Journal,* January 1947, pp. 53–58.

Since 1927 Utah has ranked second among our copper-producing states, virtually all of its copper being mined in the Bingham district, which in 1953 had an output of 269,000 tons, or about six times that of Butte. About 150 miles southwest of Bingham Canyon is another huge porphyry deposit at Ely in eastern Nevada, which in 1953 yielded 62,000 tons of copper.

Fabrication and ownership in the East. In recent years the refining of copper in the West has increased. About 44% of the nation's refining capacity is now located in the West, 6% in Michigan, and 50% along our northeastern seaboard (see Table 22:2). On the other hand, the fabrication of refined copper remains entrenched in the East. Today the output of approximately 300 mines moves through 19 smelters and 15 refineries en route to final manufacture.

The United States copper industry is dominated by a few large companies. Kennecott, Anaconda, and Phelps Dodge control nearly 85% of the nation's copper reserves and mine over 75% of the ore. The Kennecott Copper Corp. is the largest producer of ore, and its mines yield about 45% of all newly mined copper in the United States. More than 90% of the nation's smelting capacity is controlled by four companies: American Smelting & Refining, Anaconda, Phelps Dodge, and Kennecott. Furthermore, refining and fabrication are controlled very largely by the same four companies.[6] Thus, while copper mining has migrated into the West, the purse strings of the industry are held by widely scattered stockholders. But control stays in eastern financial centers.

5. SOUTH AMERICAN DEVELOPMENTS

The great copper hill at Chuquicamata. Chile is endowed with copper reserves that apparently are surpassed only by those of the United States (see Table 22:3). For years Chile ranked second to this country in copper production, but in 1953 Chile yielded second place to Northern Rhodesia. Furthermore, Chilean copper exports are the largest in the world, and Chilean copper now supplies about

[6] For a discussion of the role of corporations and cartels in the copper industry, see U. S. Federal Trade Commission, *Report on the Copper Industry,* Washington, 1947; "The World of Kennecott," *Fortune,* November 1951, pp. 89–93 ff.; and U. S. Bureau of Mines, *Materials Survey on Copper,* Washington, 1952, Chap. VI, pp. 13–23, 76–81.

35% of the requirements of the United States.

Greatest of Chilean deposits is Chuquicamata, situated in the Desert of Atacama on the slopes of the Andes about 10,000 feet above sea level and connected by railroad with the ports of Antofagasta and Mejillones. Chuquicamata Hill contains at least 20 million tons of copper, unquestionably the greatest heap of copper known to man. The face of the hill is being blasted and shoveled away, and today there is a huge pit about 2 miles long, ½ mile wide, and 900 feet deep. Shaft and tunnel mining has begun. The ore moves in trainloads at the rate of fully 50,000 tons a day to be crushed, leached, extracted from solution, and refined into copper bars. Mining operations began in 1915, and today Chuquicamata is a well-established community of 25,000 people in spite of the fact that everything must be imported, for the desert offers no water, no food, no fuel, and no building materials.[7]

The remarkable development of Chuquicamata is a striking illustration of the fact that the conversion of a potential resource into an actual resource is frequently the result of a propitious combination of many factors. It was purely accidental that the Bolivia and Antofagasta Railway had been previously built within 5 miles of the copper hill. In 1911, when a staff of experts was sent to investigate the property, it was found that the ores could not be worked by any method known at the time, an obstacle that was soon overcome by the perfection of a new process involving leaching and electrolysis. In the building of the Panama Canal engineers learned how to use steam shovels in a big way, knowledge that proved indispensable at Chuquicamata. Fortunately, the canal was completed in 1914, thereby providing the west coast of South America with much shorter routes to eastern United States and western Europe. The power problem was solved by constructing an electric generating plant, using Californian and Peruvian petroleum as fuel, at the port of Tocopilla and by erecting high-voltage lines to conduct the power 100 miles across the desert to Chuquicamata. The water supply had to be piped from Andean streams 80 miles away. The problem of labor supply was solved by hiring unemployed workers from the desert's nitrate fields, by importing labor from the Central Valley of Chile, and by bringing in engineers, chemists, and other technical experts from the United States. Such a huge project called for a large expenditure of capital funds, and during World War I and the postwar era Europe had no capital to spare, but the necessary millions of dollars were readily obtained in the United States. Finally, it should be noted that Chuquicamata was developed at a time when the world demand for copper was increasing rapidly and prices were spiraling upward.

Other Chilean developments. Another Chilean copper-mining district is found in the southern part of the desert at Potrerillos about 90 miles east of the port of Chañaral. Here, too, many difficulties had to be surmounted before its lean ores, averaging only 1½% in copper, could be successfully mined. A third district, which at times yields one fourth of the nation's output, lies high in the Andes at El Teniente, in the vicinity of Sewell, about 50 miles southeast of Santiago. Some 2500 oxen were used to haul in the original mining equipment, and the heavy snowstorms of the region made it necessary for the company to build miles of snowsheds to protect its railroad connecting the mines with the main railroad at Rancagua. In this district shaft-mining methods are used. The processes of concentration, smelting, converting, and refining are all performed in the mining area, and refined copper is shipped to American and European markets through the ports of Valparaiso and San Antonio.

American initiative and capital have made possible the development of Chilean copper resources. El Teniente is owned by a subsidiary of the Kennecott Copper Corp., while Chuquicamata and Potrerillos are controlled by Anaconda.

[7] See William E. Rudolph, "Chuquicamata Twenty Years Later," *The Geographical Review,* January 1951, pp. 88–113.

Rock breaker in northern Rhodesia copper mine. Note storage batteries on the men's belts. ***British Information Service***

Peruvian copper. Peru is also a source of copper, chiefly through the output of the Cerro de Pasco district upon the high Andean plateau. This section was at one time dependent on pack trains, but now sends its product to the sea by means of the railroad that passes through Lima to Callao. Peruvian copper is mined largely in conjunction with silver, lead, zinc, and bismuth.

Elsewhere in South America copper mining is of minor commercial importance in the Corcoro district of Bolivia and at Famatina in the Andes of Argentina.

6. COPPER IN AFRICA

The rich ores of Katanga. In recent times the Belgian Congo and Northern Rhodesia have come to rank among the world's great producers of copper as the result of the exploitation of a rich copper belt, approximately 280 miles long and 50 miles wide, extending southeastward through the Katanga district of the Congo into adjacent Rhodesian territory.[8]

The ores of the Katanga district are oxides with an average copper content of 6½%, some of them running as high as 25%, while those of Northern Rhodesia are chiefly sulfide ores averaging 3½% in metallic content. However, the lower-grade sulfides of Northern Rhodesia are easier to smelt, and the deposits apparently contain 3 times as much copper as those of Katanga (see Table 22:3).

The mining of copper on a commercial scale began in the Katanga district in 1911 following the extension of a railroad from the south into Elisabethville and the construction of a smelter at Lubumbashi.[9] Nearly all the present output is mined in areas that center about the towns of Elisabethville, Panda, Kambove, and Ruwe. Most of the ore is worked by open-pit methods. Smelting operations have long been dependent upon imported coal, obtained chiefly from the Wankie mine in Southern Rhodesia. The entire mining district is now supplied with electricity from a hydro plant at Cornet Falls on the upper Lufira River, and since 1930 a smelter and electrolytic refinery have been in operation at Panda.

Northern Rhodesia. This part of Africa was long considered an unpromising field, because the oxidized outcrops of ore occurred

[8] See Ralph E. Birchard, "Copper in the Katanga Region of the Belgian Congo," *Economic Geography,* October 1940, pp. 428–436.

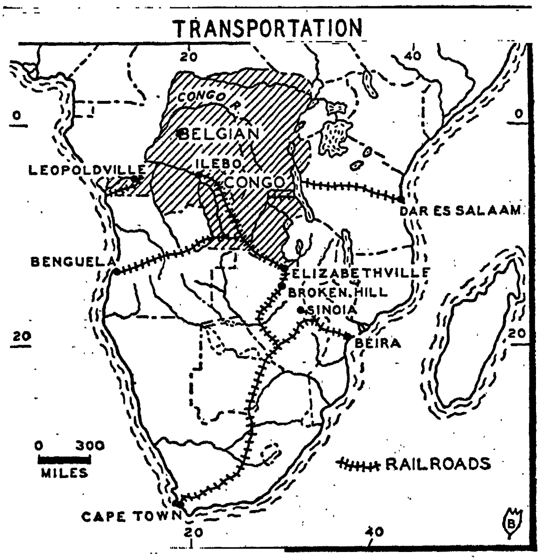
[9] In 1906 the Belgian government granted the Union Minière du Haut Katanga a concession to work an area of 7776 square miles until 1990. This enterprise, financed by Belgian and British capital, has been interested not only in the mining of copper but also in the production of tropical fats and oils and in the exploitation of silver, tin, radium, cobalt, and other minerals.

in narrow bands and averaged about 3% to 5% in metallic content. Hence it was not until the late 1920's that Rhodesian potentialities became apparent. By the end of 1930 it was established that the Northern Rhodesian field held 500 million tons of ore containing more than 20 million tons of copper. Large-scale production began with the opening of the Roan Antelope mine in June 1931, and other properties were developed soon afterward at N'Kana, Mufulira, and Rhokana. Concentrating mills and smelters were set up in these mining areas, and in 1935 an electrolytic refinery was completed at N'Kana. Since World War II a large deposit, containing 6½ million tons of copper, has been developed at N'Changa. In 1953 Northern Rhodesia surpassed Chile and came to rank second to the United States in copper production.

Because of its interior location, the Katanga-Rhodesian copper belt has from the beginning of operations been confronted with a serious transportation problem. The long and circuitous Congo River is an unsatisfactory transportation route, since its numerous falls and rapids make expensive transshipments necessary. When the Northern and Southern Rhodesian Railways extended their line to Elisabethville in 1910, the copper belt achieved economic access to the sea, and for the next 20 years most copper was shipped by rail to the Indian Ocean port of Beira in Mozambique (Portuguese East Africa).

In 1931 a new railroad reached the Katanga district from the Atlantic port of Benguela, Angola (Portuguese West Africa). This route is a more direct route to western Europe and eastern United States than the Beira route, since the overland haul is about 300 miles shorter and since the 3000-mile ocean voyage around the Cape of Good Hope is eliminated (see Fig. 391). Most of the copper traffic now moves through Lobito, which has a good harbor a few miles north of Benguela.

Elsewhere on the continent, copper production of minor importance is found in the Union of South Africa, most of the output coming from northern Transvaal.

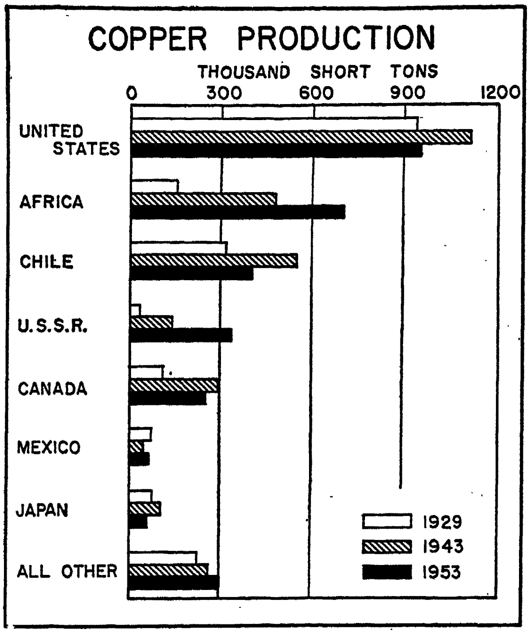


Main railways and steamboats on the Congo give access from both oceans to the mineral lands of the Congo and Rhodesia. Benguela is now using a new harbor, Lobito, a few miles north. ***Ralph E. Birchard, Economic Geography, Oct. 1940***

7. CANADIAN, SOVIET, AND OTHER DEVELOPMENTS

Canadian copper-mining districts. Nearly one half of all Canadian copper is obtained from the famous deposit of nickel-copper ore at Sudbury, Ontario, which contains about three fourths of the nation's copper reserves. Although the ore averages about 3% in metallic content and occurs in veins deep beneath the surface of the earth, the recovery of nickel, copper, and platinum makes mining operations very profitable. The mines at Sudbury, the smelters at Copper Cliff and Conniston, and a refinery at Copper Cliff are owned by the International Nickel Co. A lesser deposit of nickel-copper ore in the Sudbury district is worked by another company.

About one fourth of Canadian copper is mined in Quebec, chiefly in the Noranda district near the Ontario border. All Quebec's output is refined at Montreal, which has ready access to abundant hydroelectric power generated along the turbulent upper St. Lawrence. The remainder of the nation's copper is mined largely along the Manitoba-Saskatchewan bor-



Boom years and latest. Interesting shifts. Africa, chiefly Rhodesia and Congo, is startling. Who wins in 1975? *U. S. Bureau of Mines*

der at Flin Flon, which has both smelting and refining facilities, and in British Columbia at Allenby and Howe Sound. Concentrates from the British Columbian mines are shipped to the nearby smelter and refinery at Tacoma, Wash., which also refines copper imported from Alaska and Lower California. The great bulk of Canadian copper exports, however, consists of refined copper destined for the large industrial markets of Europe and the United States.

Mexico and Cuba. In contrast with Canada and the United States, Mexico and Cuba are unimportant producers. The chief mining districts of Mexico are at Cananea, Sonora, an extension of the Arizona field, and at Santa Rosalia on the peninsula of Lower California. In Cuba the Matahambre mine in Pinar del Rio is the leading producer. Mexico produces 60,000 to 70,000 tons of copper a year, or three times as much as Cuba. Most Mexican copper and all the Cuban output are exported to the United States.

Production in Europe. European countries have been mining copper for many centuries, but they play a minor role in copper production today. Excluding the Soviet Union, the combined output of all the nations of Europe in 1948–53 averaged only 125,000 tons a year, or less than 5% of the world's newly mined copper.[10] Yugoslavian mines at Bor (Moravska Banovina) account for one third of all copper mined west of the Soviet Union, the remainder being produced almost entirely in Finland, Sweden, Norway, and Spain.

The Soviet Union. The remarkable expansion of Russian industry during the 1930's was accompanied by an extensive development of power resources, a great increase in the production and use of electricity, and an ensuing increase in the demand for copper. To satisfy this growing demand, domestic copper production had to be supplemented by imports, and a big effort was made to locate and exploit new deposits. Whereas in the early 1930's about three fourths of all copper was mined in the Ural Mountains, production thereafter expanded southeastward into Kazakhstan, which contains more than five eighths of the nation's known reserves.[11]

In recent years Kounrad and Djezkazgan, to the north and west of Lake Balkhash, have become the leading copper-mining districts, the large deposits of low-grade porphyry ores being easily worked with open-pit methods. Copper is also mined in the middle Volga region and on the Kola Peninsula.

In 1953 Russian ores yielded 335,000 tons of copper or about 10% of the world's supply. The Soviet Union is apparently self-sufficient in copper and ranks fourth among all nations in both production and reserves (see Fig. 392 and Table 22:3).

Japan and Australia. The vast continent of Asia, excluding the Soviet Union, has less

[10] American Bureau of Metal Statistics, *Year Book of the American Bureau of Metal Statistics, 1953,* New York, 1954, p. 7.

[11] See Guy C. Riddell and G. D. Jermain, "Russian Copper," *Engineering and Mining Journal,* December 1934, pp. 547–551, and February 1935, pp. 82–87, and George B. Cressey, *Asia's Lands and Peoples,* McGraw-Hill Book Co., New York, 1951, p. 290.

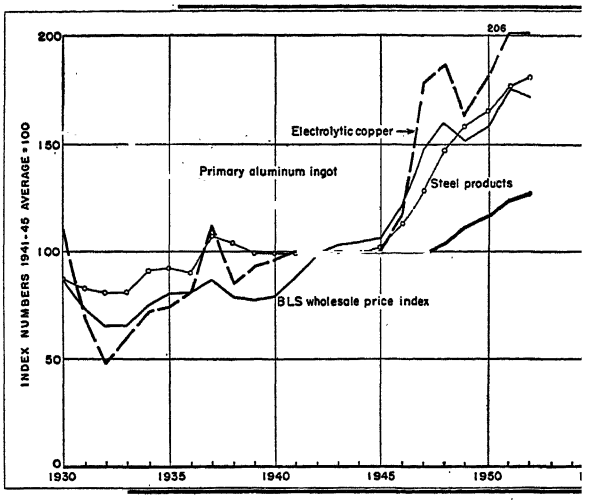
than 2% of the world's known copper reserves and produces only 4% of the world's copper. Japan leads the Orient in production with an annual output of about 65,000 tons, most of which comes from a few mines on the island of Honshu. However, the growing demands of industry have made it necessary for Japan to import copper ever since World War I. In Australia copper is mined in the Mount Lyell district of Tasmania and the Mount Morgan and Mount Isa districts of Queensland, the total output amounting to about 40,000 tons a year.

8. COPPER RESOURCES AND WORLD TRADE

Distribution and ownership of reserves. Although nearly every country has some copper deposits, nature did not distribute copper with an impartial hand. Fully 90% of the world's known commercial copper reserves are concentrated in the United States, Chile, Northern Rhodesia, the Soviet Union, Canada, and the Belgian Congo (see Table 22:3). These six countries produce more than 85% of all newly mined copper (see Fig. 392).

Corporate ownership is even more highly concentrated. United States, British, and Belgian interests control not less than 83% of the world's copper reserves. American corporations control 50% of the world's reserves by their holdings in the United States and Latin America, and they have additional investments in Canada and Northern Rhodesia. British interests control 26½% within the British Empire and also own properties in Spain. Belgian and British interests own the reserves of the Belgian Congo, or about 7% of the world's supply.[12]

The chief copper reserves are located far from the great markets of western Europe and eastern North America. Fully 90% of the unmined copper is in south-central Africa, Chile, western United States, the Kazakhstan region of Siberia, and eastern Canada. Only



Bureau of Labor Statistics index shows two trends in metal. During this period aluminum has experienced more technological progress than the others. ***U. S. Bureau of Mines***

the eastern Canadian deposits are near major markets. Only the Chilean deposits lie near the sea. Hence, inland transportation facilities are of vital importance, and more than 75% of the world's newly mined copper uses cheap ocean transport en route to market. In the United States most western copper moves by rail to Pacific ports and thence by ocean vessel via Panama to fabricating plants along the Atlantic seaboard.[13]

Above-ground reserves are of growing importance. Most of the old copper scrap is recovered in the older and greater industrial nations, such as the United States, Great Britain, Germany, and France. Old copper scrap is most abundant where depreciation and obsolescence have occurred on a large scale and over a long period of time.

Imports and exports. More than 85% of the world's copper is consumed by eight nations—the United States, Great Britain, the Soviet Union, Germany, Canada, France, Japan, and Belgium. The so-called underdeveloped countries do not appear in this list. Canada is the only major consumer with a

[12] Three American corporations—Anaconda, Kennecott, and Phelps Dodge—control 41% of the world's reserves. See Federal Trade Commission, *op. cit.*, p. 37. They can invest surplus in continuous exploration.

[13] Bureau of Mines, *op. cit.*, Chap. III, p. 3.

surplus for export. The Soviet Union is apparently self-sufficient, but it probably obtains a few thousand tons of copper a year from its satellites. All other major consumers are vitally dependent upon imports.

The United States has been a net importer of copper since 1941, and its imports are now the largest in the world. Its copper imports amount to nearly 700,000 tons a year and are obtained chiefly from Chile, Canada, Peru, and Mexico. Great Britain ranks second in imports and is supplied mainly by Northern Rhodesia and Canada. Germany, France, Belgium, Italy, and the other free nations of Europe import much of their copper from the Belgian Congo, Chile, Northern Rhodesia, and Cyprus.

The United States led the world in copper exports from 1881 until 1931, but is now surpassed by Northern Rhodesia, Chile, and the Belgian Congo. American exports consist almost entirely of refined copper in the form of cathodes, ingots, and bars, and such fabricated products as pipes, tubes, plates, sheets, rods, cable, and wire.

Ores, concentrates, and matte dominate the exports of only a few minor producers, such as Cyprus, Cuba, Bolivia, Formosa, and the Philippines. Nearly all exports now consist of blister and refined copper. Because of their purity and value, blister and refined copper are virtually footloose and can stand transportation charges to almost any market in the world.

The position of the United States. The United States has long played the leading role in the world's copper economy. One fourth of the world's known reserves lie within our borders, and another fourth is owned by American corporations in foreign lands. One third of all newly mined copper now comes from American mines. About one half of the world's refining capacity is located here. About 46% of the world's total copper consumption occurs in the United States.

In certain important respects the position of the United States has changed. Our preeminence as a producer of copper has waned, while our dominance as a consumer has increased. Domestic production has failed to keep pace with demand, and our dependence upon imports has increased. A sizable segment of our copper-mining industry has joined the ranks of high-cost producers. Apparently the days of the electric shovel are numbered, for it is said that the open-pit mine will be the exception 30 years from now.[14] It is estimated that our known reserves, plus extensions and discoveries, cannot maintain an annual production of more than 800,000 tons of copper over the next 25 years.[15] Larger imports are inevitable. The years of indefinite plenty are gone (see Fig. 384).

[14] *Ibid.*, p. 11.

[15] The President's Materials Policy Commission, *Resources for Freedom,* Washington, Vol. 2, 1952, p. 34.

23· Aluminum, Tin, Nickel, and Other Mineral Industries

1. ALUMINUM

A meteoric young giant. Prehistoric man discovered copper and used it, but the production and use of aluminum are entirely the result of modern scientific research. Aluminum was first isolated from its ore in 1825 by Hans Christian Oersted, a Danish scientist. In 1845 Friedrich Wöhler, a German, succeeded in analyzing the metal and found it to be exceptionally light.

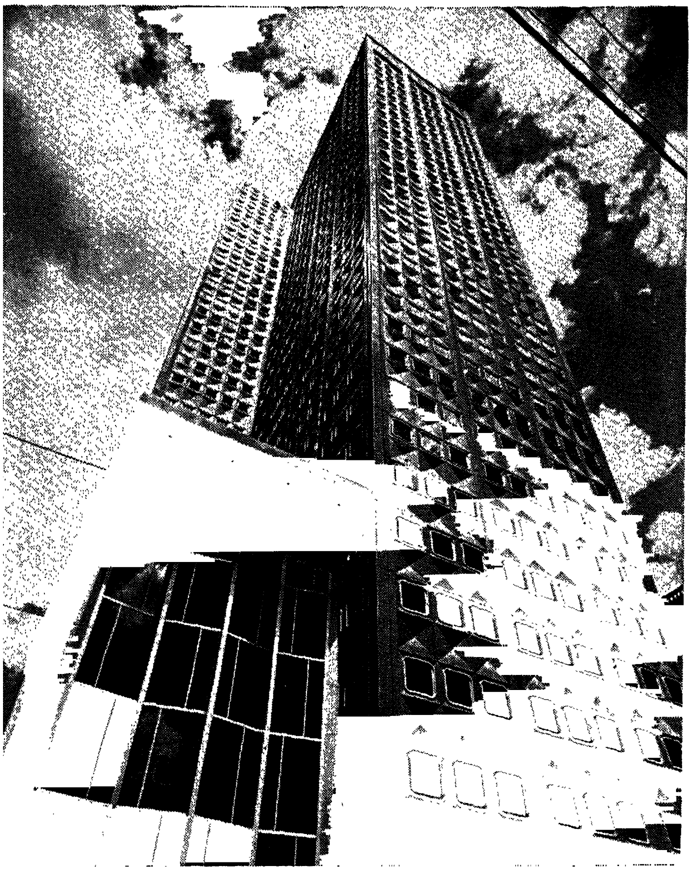
Aluminum remained a laboratory curiosity until Henri Sainte-Claire Deville, a French chemist, made improvements permitting small-scale production. As a result, the price dropped from \$545 a pound in 1852 to \$17 in 1859, but aluminum was still a precious metal used chiefly for jewelry and novelties. Between 1859 and 1886 the world's output increased from 2 to 16 tons, and the price declined to \$8 a pound.

The problem of producing low-cost aluminum continued to baffle the scientific world until February 23, 1886, when Charles Martin Hall, a 22-year-old graduate of Oberlin College, turned to electricity as the best means of reducing aluminum oxide to metallic aluminum. Only two months later Paul Héroult, a young Frenchman, made the same discovery.

In 1888 the Pittsburgh Reduction Co., which later became the Aluminum Company of America, began commercial production with the Hall-Héroult process, aluminum selling for \$5 a pound. With further technological improvements, the development of large-scale production, and a steady reduction in the cost of electric power, the price of ingot aluminum continued slowly downward, decreasing from 59¢ a pound in 1895 to 27¢ in 1913, and to 15¢ in 1941. In 1950–53 the price ranged between 17¢ and 21½¢ because of higher costs and a big demand.

As the price declined and as the useful properties of the new metal came to be more widely appreciated, the demand increased, and the world's production of aluminum expanded from 1800 metric tons in 1895 to 64,000 tons in 1913, and to 2,644,000 tons in 1953. The United States now produces 47% of the world's aluminum; Canada, about 25%; while the Soviet Union, France, Germany, Norway, and Italy account for most of the remainder.

Qualities and uses of aluminum. The outstanding quality of aluminum is its light weight: a cubic foot of aluminum weighs only 167 pounds as compared with 556 pounds for copper and 487 pounds for ordinary steel. Aluminum is soft and can be easily shaped by rolling, forging, casting, extrusion, or drawing, and it is easily welded. Furthermore, the metal is a good conductor of heat, is only slightly inferior to copper as a conductor of electricity, and unites easily with copper and



Proud Alcoa's new Pittsburgh home, 31-story office building made chiefly of aluminum. Hundreds of tons less of steel skeleton. Outside wall consists of aluminum panels hung from within; inside, ditto. Aluminum windows turn on vertical axis. Many aluminum furnishings. *Aluminum Company of America*

other metals in the formation of alloys. Because of its affinity for oxygen, it is used to separate other metals from their oxides, such as chromium, manganese, tungsten, and vanadium. About ½ pound of aluminum, chiefly remelted scrap, is used to deoxidize and purify each ton of molten steel.

In 1953 the United States consumed 1,615,000 short tons of aluminum, a sevenfold increase since 1940. Fully 60% of all aluminum is used for transportation (air, land, and sea), building materials, power transmission, household appliances, and cooking utensils.

The lightweight metal is indispensable in aircraft production, for about three fourths of the weight of an airplane is aluminum. It is being used increasingly in automobiles, trucks, trailers, buses, railway cars, and ships.

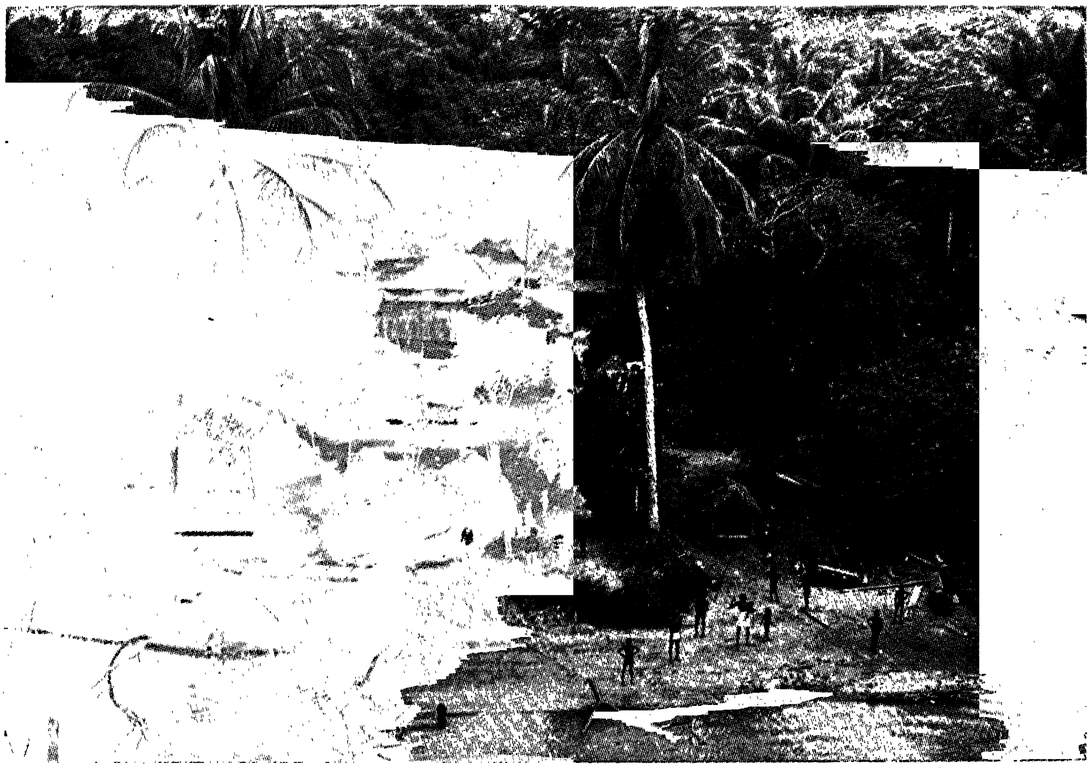
Since World War II the construction industry has come to rival transportation as the major consumer of aluminum, which is now widely used for roofing, siding, store fronts, doors, windows, screens, and skylights. In the construction of skyscrapers, aluminum structural shapes save weight and reduce the amount of excavation and foundation work.

TABLE 23:1. Bauxite Reserves in the Free World

	Reserves (millions of metric tons)	Grade (% alumina)	Contained metal[a] (millions of metric tons)
United States	50[b]	50	10
British Guiana	65	61	17
Haiti and Dominican Republic	30	47	6
Jamaica	315	50	67
Surinam	50+	59	13+
Subtotal	510	..	113+
India	250	60+	64+
Gold Coast	230	53	51
Brazil	150	61	41
Yugoslavia	100	60	26
France	60	61	16
Greece	60	57	15
French West Africa	50	60	13
Others	90	47	36
Subtotal	990	..	262+
Total free world	1500	..	375+

a Assumes 85% recovery of alumina from bauxite, and 2 tons of alumina per ton of aluminum.
b Includes 10 million tons of ferruginous bauxite in Oregon, containing 35% alumina. This ore is low in silica but is not as yet commercial.
Source: U. S. Geological Survey and Bureau of Mines, cited in The President's Materials Policy Commission, *Resources for Freedom,* Washington, Vol. 2, 1952, p. 69.

Steel-cored aluminum cables have virtually displaced copper in high-tension power lines, for the light weight of aluminum cables permits the supporting towers to be spaced farther apart, thereby lowering the cost of constructing and maintaining power lines. Aluminum is also replacing copper in secondary distribution lines, building wire, motor and



Wet tropic landscape. Aluminum climate, p. 48. Surinam: Djukas, descendants of runaway slaves, watch ore boat go by, too free and too happy to dig the white man's bauxite. ***Aluminum Company of America***

generator windings, and many types of electrical machinery.

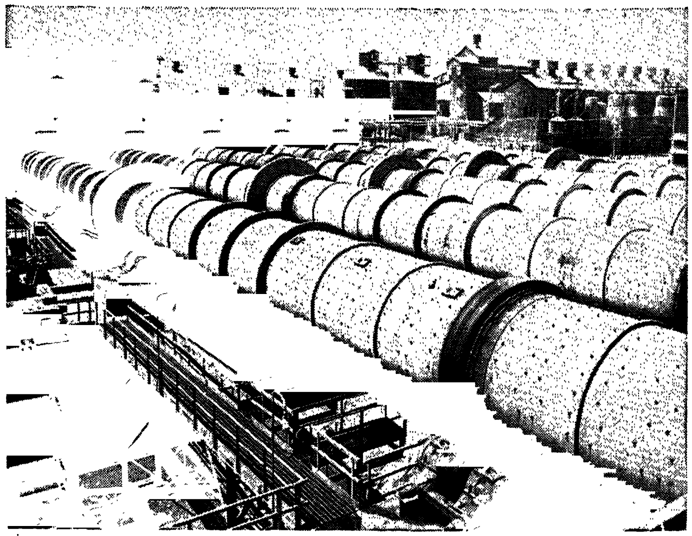
In times of war the use of aluminum for household appliances, cooking utensils, furniture, paint, foil, collapsible tubes, and other nonessential articles is curtailed. At such times most aluminum is needed for aircraft.

Bauxite production and reserves. In spite of the fact that aluminum is the most abundant metal to be found in the earth's crust, existing in great quantities in common clay, bauxite thus far has proved to be the only ore from which aluminum can be produced economically on a large scale. The aluminum oxide content of high-grade bauxite ranges from about 50% to 65%, in contrast with clay, alunite, anorthosite, and leucite that contain only 20% to 35%.

Bauxite is mined by both open-pit and underground methods. The ore is taken to a nearby mill, where it is crushed, washed, dried in rotary kilns, and screened prior to shipment. Of the world's output of 14 million short tons in 1953, about 26% was mined in Surinam (Dutch Guiana), 17% in British Guiana, 13% in the United States, and 10% in Jamaica. The remainder was obtained chiefly in France, Hungary, the Soviet Union, Yugoslavia, and French West Africa.[1] Over 90% of the U. S. production occurs in Pulaski and Saline counties, Arkansas, but two thirds of our bauxite supply comes from the Guianas.

The bulk of the world's bauxite reserves are located in the tropics (see Table 23:1), because the heavy rains leach out more soluble earth materials. In 1952 mining operations began in Jamaica, site of the largest known reserves. New deposits are being developed in the Dominican Republic, Haiti, the Gold Coast, and French Guiana.

[1] The American Bureau of Metal Statistics, *Year Book of the American Bureau of Metal Statistics, 1953,* New York, 1954, p. 94.



(Left) Rotary kilns, lined with fire brick, filled with gas fire, 1800°-2000° F., red mud, limestone, and soda to produce alumina. Aluminum eats fuel. *(Below)* Electrolytic cells in the pot room of a smelting plant at Massena, N. Y. St. Lawrence power. *Aluminum Company of America*

In view of the rapidly growing demand, American bauxite reserves are small. In fact, were it not for the wartime development of a process for treating high-silica ores, United States reserves would now be fairly close to exhaustion.[2] In Europe the largest reserves are those of Hungary, Yugoslavia, and France. Hungarian reserves are being exploited for the benefit of the Soviet Union, which apparently is poorly endowed with bauxite.[3]

Since bauxite is a bulky, low-valued commodity, cheap transportation is essential. The bauxite of the tropics is carried away from the mining areas in ocean vessels. The movement of European and U. S. bauxite is facilitated by short rail hauls and use of inland waterways.

[2] The President's Materials Policy Commission, *Resources for Freedom,* Vol. 2, 1952, p. 71.

[3] Hungarian reserves are estimated at 250 to 300 million tons, about 10% consisting of high-grade bauxite. Russian reserves do not exceed 30 million tons, almost all of which is believed to be of low grade. Richard Redler, *Aluminum in World Affairs,* Canadian Association for Adult Education and Canadian Institute of International Affairs, Toronto, 1951, p. 7.

The extraction of alumina. The production of aluminum involves two distinct steps: (1) the extraction of alumina from bauxite and (2) the reduction of alumina to metallic aluminum. Four to 6 tons of bauxite are needed to produce 2 tons of alumina, or aluminum oxide. Two tons of alumina yield 1 ton of aluminum.

Most alumina is obtained with the Bayer process, which can handle bauxite ores that are rich in alumina and low in silica. The ore is ground to a powder and treated with a hot solution of caustic soda. The solution is then filtered, cooled, precipitated, and dried, to get alumina ready for the smelter.

The new Alcoa[4] combination process, using caustic soda and lime, permits the recovery of alumina from low-grade bauxite with a silica content of 7% to 13%. It is also used to reclaim alumina from the red-mud residue formerly wasted in the Bayer process. In either process the fuel may be coal, lignite, fuel oil, or natural gas.

Some alumina plants are located near bauxite mines. Most of them, however, are oriented toward fuel and are located at tidewater sites or along navigable rivers so that bauxite may be assembled at low cost.

The production of aluminum. The reduction of alumina to aluminum is achieved with the Hall-Héroult process. In every reduction plant are long rows of electrolytic cells, each cell producing about 500 pounds of aluminum a day. Every cell contains a cryolite bath, and alumina is added from time to time. The passage of an electric current through the solution breaks down the alumina into aluminum and oxygen, molten aluminum being deposited at the bottom of the cell. The aluminum is tapped into a large ladle from which it is cast into pigs of 50 pounds each.

Since pig aluminum contains some dross and bath material, these impurities are removed by a remelting process. At this time alloys may be added, and the metal is cast into ingots that are ready for fabrication.

The plant that produces aluminum is a hog for electric power. In 1952 the U. S. aluminum industry used more electricity in one day than would be needed to supply a city of 65,000 homes for a whole year.

To obtain cheap electricity, most aluminum plants have been located near water-power sites, which sometimes are remote from the alumina-producing plant and the market for aluminum. In recent years an increasing number of aluminum plants have been supplied with electricity from steam plants using mineral fuels. The higher cost of power at these plants is offset by lower transportation costs resulting from better plant locations.

To meet the diverse needs of modern industry, pig and ingot aluminum must be converted into many shapes. This is accomplished in fabricating plants that are usually located in major market areas.

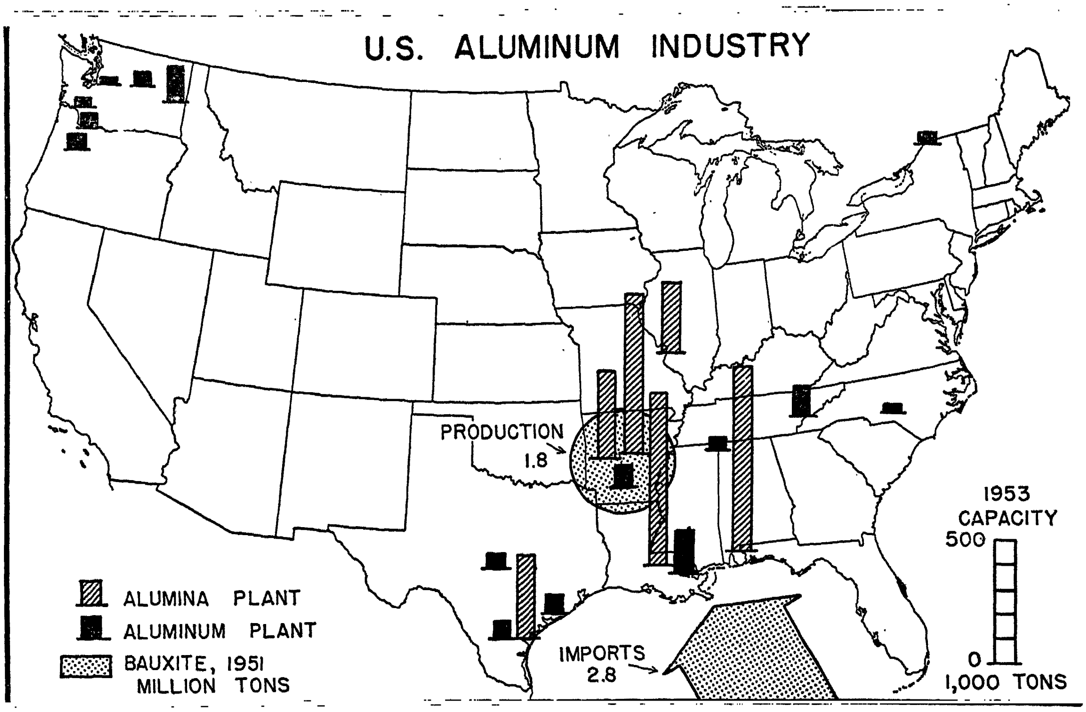
The United States aluminum industry. Although aluminum now sells at a low price, its production involves a huge investment. For example, Alcoa has invested hundreds of millions of dollars in bauxite mines, ocean vessels, water-power sites, alumina and aluminum plants, fabricating plants, and costly research. This is not a business for the small entrepreneur.

For many years Alcoa was the sole producer of alumina and aluminum in the United States. With government aid, the Reynolds Metals Co. entered production in 1941 and was followed five years later by the Kaiser Aluminum & Chemical Corp. Alcoa produced about 48% of the nation's primary aluminum in 1953; Reynolds, 26½%; and Kaiser, 25½%.

In 1953 the aluminum plants were located chiefly in Washington and Oregon, using Columbia River power; in Texas, Louisiana, and Arkansas, using natural gas and lignite; in the TVA water-power area of Tennessee and Alabama; and at Massena, N. Y., near St. Lawrence power (see Fig. 400 top).

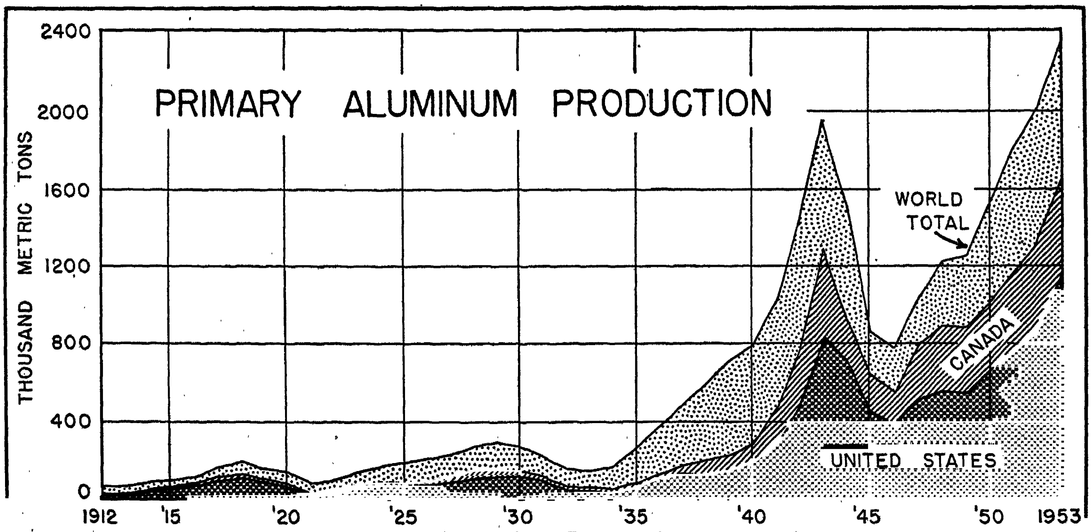
Bauxite from the tropics, especially Guiana,

[4] The trade name Alcoa is used to designate the Aluminum Company of America, as the name is widely used by the company, the government, the courts, and the general public. For a history of the company, see Charles C. Carr, *Alcoa: An American Enterprise*, Rinehart & Co., New York, 1952.



(Above) Different locational requirements mean scattered facilities. For aluminum metal, power is 20% and transportation 11% of total costs. Bauxite (imported and domestic) moves to alumina plants. Alumina moves to aluminum plants at cheap power along Columbia, Tennessee, and St. Lawrence rivers, and near natural gas. The Northwest will soon import alumina from Jamaica. Aluminum metal, some from Canada, is shipped to fabricators mostly in the industrial Northeast. Question: will atomic power be cheap enough to permit location of aluminum (and alumina?) plants nearer to market, thus saving transport costs? Time will tell. *Sources: Yearbook of the American Bureau of Metal Statistics, 1954; U. S. Bureau of Mines, Minerals Yearbook, 1952, and Materials Survey—Bauxite, 1953*

(Below) Aluminum is so new. Production awaited price decline and demand (see Fig. 393), price depended on technology. Compare 1935 and 1953 as to amount and location. Cheap North American power wins. See Kitimat (Figs. 12, 15, and 36). *Sources: as above.*



is carried in barges from New Orleans upstream to the alumina plant at East St. Louis. It is delivered by ocean vessels directly to the plants at Mobile, Ala., Baton Rouge, La., and Corpus Christi, Tex., while that destined for Listerhill, Ala., moves inland by rail from Mobile.

Ten aluminum-reduction plants, using hydroelectric power, in 1953 accounted for 52% of the nation's ingot-producing capacity. Six of these plants use the power of the mighty Columbia River. One plant at Rockdale, Tex., is now using lignite. It is predicted that primary aluminum capacity may expand not only in the Pacific Northwest but also in the lignite regions of the Great Plains and the low-cost coal regions of Tennessee and the Ohio Valley.[5]

The Canadian aluminum industry. The production of alumina and aluminum in Canada is in the hands of a single producer, the Aluminum Company of Canada. Production is concentrated along the Saguenay and St. Maurice rivers, tributaries of the St. Lawrence. The company operates a huge alumina-aluminum plant at Arvida on the Saguenay and aluminum-reduction plants at Isle Maligne on the upper Saguenay, at Shawinigan Falls and La Tuque on the St. Maurice, and at Beauharnois on the St. Lawrence above Montreal. These plants lie near great water-power sites and are able to assemble their materials cheaply by water transportation.

The Arvida plant is the world's largest and cheapest producer of ingot aluminum. It has an annual capacity of 360,000 tons, as compared with the 200,000 tons of the plant at Chalmette, La., the largest in the United States. It is supplied with power from two hydro plants at Shipshaw, less than 5 miles away. One of these hydro plants has an installed capacity of 1,200,000 h.p. and is surpassed in size only by the power plants of the Hoover and Grand Coulee dams.

A giant aluminum-reduction plant is under construction at Kitimat, British Columbia about 350 miles north of Vancouver. It will use local hydroelectric power and will obtain alumina from a new plant in Jamaica, the first alumina plant to be built in the tropics.

Canada leads the world in the export of aluminum, chiefly in the form of ingots, blooms, bars, rods, and sheets. Exports amount to more than 400,000 tons annually and are destined largely for the United States and Great Britain.

The aluminum industry of Europe. Although the Soviet Union did not begin aluminum production until 1932, it emerged from World War II as the world's third largest producer. Indeed, production increased from 98,500 to 275,000 short tons between 1946 and 1953. Alumina-aluminum plants are now in operation at Kamensk and Krasnoturinsk in the Urals, at Volkhov to the east of Leningrad, at Zaporozhe on the Dnieper River, at Kandalaksha along the White Sea, and at Erivan near Mt. Araat. Inferior ores and high transportation costs are the chief handicaps to production.[6]

France is well endowed with high-grade bauxite and normally exports about one half of her output as ore or alumina to Great Britain, Germany, Norway, and Switzerland. At present France leads the nations of western Europe in alumina and aluminum production. French alumina plants are located near the bauxite mines along the Mediterranean Sea. Aluminum is produced near water-power sites along the slopes of the Alps and Pyrenees.

At the outbreak of World War II, Germany was the world's largest producer and con-

[5] The President's Materials Policy Commission, *op. cit.*, p. 68. In August 1952 Alcoa announced plans for an aluminum-reduction plant and hydroelectric project to be built near Skagway, Alaska. Anaconda is building a 50,000-ton reduction plant near Columbia Falls, Mont.; it will cost $45 million and is expected to begin production by 1955. The Harvey Machine Co. is building a 52,000-ton plant at The Dalles, Ore.

[6] The best bauxite is mined in the southern and central Urals. The Volkhov plant uses low-grade bauxite from the nearby Tikhvin district. Zaporozhe depends upon Tikhvin, 1000 miles to the north, and distant Hungary. Kandalaksha utilizes the nepheline syenite tailings of apatite mines on the Kola Peninsula. Erivan uses local alunite.

sumer of aluminum and also the leading importer of bauxite. Since 1951 West Germany has ranked second to France among western European producers, alumina and aluminum plants being concentrated in the Rhineland and Bavaria. Production in East Germany is believed to be very small.

Norway is a major producer and exporter of ingot aluminum because of the advantage of cheap hydroelectric power near good seaports. Six aluminum plants and one alumina-aluminum plant at coastal sites import their materials cheaply and ship nearly all their output to foreign markets.

The Italian aluminum industry is concentrated on the Po plain and Alpine slopes, a few plants being located in the central Apennines. The industry is supplied with imported coal and hydroelectric power from mountain streams. Bauxite is obtained from the Istrian peninsula (ceded to Yugoslavia in 1947) and from deposits in the central Apennines and along the Gulf of Manfredonia. In 1953 the Italian output of 61,000 short tons of aluminum exceeded that of Japan, Great Britain, and Switzerland, the only other producers of importance.

2. MAGNESIUM

The rise of magnesium production in Germany. Magnesium even more than aluminum is a newcomer in the metallurgical world. Like aluminum, it is distinctly a product of scientific research, and its outstanding quality is its lightness. Magnesium weighs only two thirds as much as aluminum, less than one fourth as much as steel, and only one fifth as much as nickel or copper.

In 1852 a German scientist, Robert Bunsen, derived pure magnesium by the electrolysis of fused magnesium chloride, and German chemists, eager to make full use of the great potash deposits at Stassfurt, found that they could use carnallite, a hydrous chloride of magnesium and potassium that is obtained cheaply as a by-product of potash production. In 1886 the first electrolytic magnesium plant, using carnallite as a raw material, began commercial production at Hemilingen near Bremen, and ten years later a larger plant was established at Bitterfeld.

It was found that pure magnesium in the molten state ignites and burns very easily, that the pure metal has little strength and is practically worthless as a structural raw material, but that magnesium alloyed with other metals has great strength and durability. The Germans learned how to alloy magnesium with aluminum, zinc, and other metals; they developed the precise techniques needed in production and fabrication; and in time they came to make extensive use of the new metal in the manufacture of airplanes, automobiles, electrical equipment, and many types of machinery.

In 1938 Germany produced 14,900 metric tons of ingot magnesium, or 60% of the world's total. Bitterfeld, Stassfurt, Aken, and Heringen were the chief centers of production. Today the largest potash deposits are in East Germany, and most magnesium plants have been dismantled by the Russians. The Heringen plant in West Germany is idle. In 1952 West Germany recovered 3698 metric tons of magnesium from scrap, but its production of primary magnesium was nil.

The U. S. magnesium industry. With the outbreak of World War I in 1914, the United States was unable to import magnesium from Germany, and the price of the metal on the American market soon rose from $1.14 to $5 a pound. Commercial production began at Midland, Mich., in 1915, when the Dow Chemical Co. obtained magnesium electrolytically from heavy brines that lie in strata 1500 to 5000 feet below the surface of the earth.

The demand for magnesium in this country grew slowly. In 1938 production amounted to only 3200 short tons, ingot magnesium selling for 30¢ a pound. Following the outbreak of World War II, magnesium was needed in unprecedented quantities for the production of aircraft and incendiary bombs, as an aluminum alloy, as a deoxidizer of nickel, and in the manufacture of flares, tracer bullets, photographic materials, and other supplies.

Two privately owned plants and 13 govern-

velopments occurred at Freeport and Velasco, Tex., where the Dow Chemical Co. established huge plants for the recovery of magnesium from sea water. Since only 4 out of 1000 parts of sea water consist of magnesium chloride, crystallization was impractical. Along the seashore were built huge settling tanks into which millions of gallons of sea water are poured and mixed with tons of crushed, calcined oyster shells. The magnesium chloride of the water unites with calcium hydroxide of the shells to form pools of chalky magnesium hydroxide, or simple milk of magnesia, which in turn is thickened, cleansed, and treated with hydrochloric acid to yield magnesium chloride. After drying, the chloride is fed into electrolytic cells, where it is reduced to metallic magnesium (see Fig. 403).

The reduction of magnesium, like aluminum, is a glutton for electric power, requiring 9 to 10 K.W.H. per pound of metal. The Freeport and Velasco plants obtain electricity from steam plants using natural gas as fuel.

Because of Dow's faith in the sea, man now has an inexhaustible supply of magnesium, provided he can get cheap power to smelt the chloride. The sea has yielded the cheapest magnesium that has been produced to date. The world's oceans contain countless tons of metals, and the recovery of magnesium is merely a tiny beginning. Many mineral frontiers in the future may lie along the sea.

Magnesium faces the future. Ingot magnesium is cheap. During 1943–49 it sold for 20½¢ a pound. In 1953 it was worth 27¢ a pound, as compared with 21½¢ for aluminum. Per cubic foot, it is cheaper than aluminum. Ingot magnesium, however, is more costly to fabricate, and the price of a magnesium product depends more upon fabricating costs than upon the cost of ingot metal.

The commercial use of magnesium has been retarded by the inelasticity, low tensile strength, and low corrosion resistance of its alloys as compared with aluminum, the inflammability of magnesium cuttings and dust in machining, and the price of rolled and fabricated products. As alloying and fabrication are improved, the demand for magnesium will increase.

Approximately one half of all magnesium is now used by the aircraft and aluminum industries. Its military usefulness has been proved. In times of peace, magnesium alloys will play an increasing role in the reduction of the weight of aircraft, railway cars, automobiles, bicycles, baby carriages, home and office furniture, tools, machines, and gadgets galore.

3. TITANIUM

Titanium metal. Titanium is indeed a newcomer in the family of light metals. Heavier than aluminum, it is four times stronger, much harder, and less susceptible to corrosion. It is almost as strong as steel, weighs about half as much, resists corrosion by sea water, and withstands mechanical shock and abrasion better than many of the best alloy steels. It is nearly as rust-proof as platinum. Its strength-weight ratio is said to exceed that of any other metal. Because titanium combines many of the best features of other metals, it is being hailed as the "wonder metal."

Like all infant prodigies, titanium shows great promise but needs plenty of development before that promise can be fulfilled. Titanium alloys lose their strength rapidly at temperatures above 800°F. Difficulties in fabrication remain. Ingot production in this country amounts to only 3400 tons a year. Ingot metal in 1953 sold for $5 a pound; sheet metal, for $15. Because of its lightness, strength, and corrosion resistance, most titanium metal is being used for the manufacture of jet airplanes and ordnance.

Titanium dioxide. In the form of powdered dioxide, titanium has been used since 1915 as the preferred pigment for white paints, owing to its superior whiteness and opacity. It is also used as a coating for welding rods, in the manufacture of alloys and carbide, and for white ceramics.

Titaniferous ore. The world is plentifully supplied with ilmenite, the principal titanium-bearing ore. About half the world's ilmenite is mined in the United States, chiefly in New

York, Florida, North Carolina, and Virginia. Among the major foreign producers are India, Norway, and Canada. In 1950 large-scale mining began near Lake Allard, about 400 miles northeast of Quebec. This deposit is being developed by the Kennecott Copper Corp. and the New Jersey Zinc Co. and is said to be the largest ilmenite deposit in the world.

4. TIN

The uses and production of tin. Despite the popular impression that it is hard and tough, tin is really the softest of our commonly used metals. Because of its softness and malleability, tin can be rolled into sheets only 2/10,000 of an inch in thickness. Tinfoil is nothing but pure tin rolled out into thin sheets, while the "tin" can is a steel can with a thin coating of tin.

The metal is valuable chiefly because it is airtight and does not rust, therefore making a good protective covering for sheet iron and steel in manufacturing so-called "tin" cans, tin roofing, and many other articles. In the canning of fruits, vegetables, and other products, the tin-coated can is invaluable because it excludes every bit of air, while air can get through the pores of thin steel. Since prehistoric times tin has been alloyed with copper to make bronze; it is fused with lead to make solder; and it is alloyed with copper and antimony in the production of Babbitt metal, commonly used in the manufacture of bearings.

Luckily new applications of science to industry have not increased the use of tin as rapidly as they have of copper, nickel, iron and many other metals. Any greatly enlarged demand might create an acute tin famine.

In 1951–53 the world's output of newly mined tin averaged about 172,000 long tons annually, as compared with 184,000 tons in 1937–39. About 33% was mined on the Malay Peninsula, 20% in Indonesia, 20% in Bolivia, and 9% in the Belgian Congo, while the remainder was produced chiefly in Thailand, Nigeria, and China. Approximately 90% of the world's tin is smelted in Malaya, the United States, Great Britain, and the Netherlands.

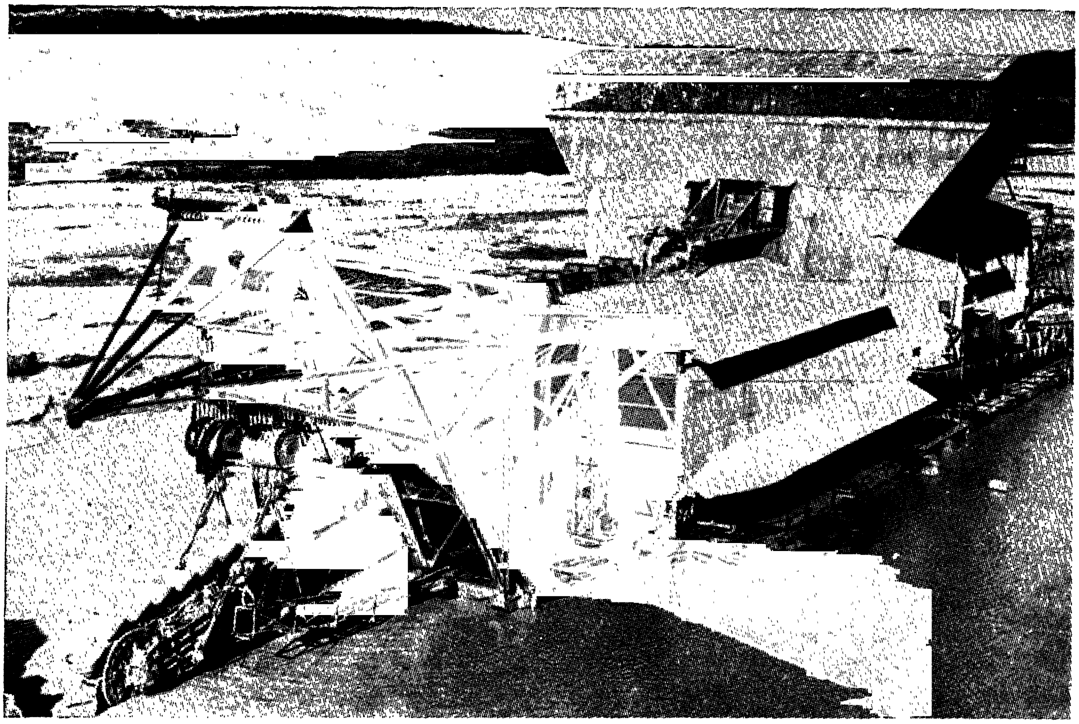
The tin industry of British Malaya. For many years the tin-bearing alluvial gravels of the Malay Peninsula have been worked by thousands of Chinese in a primitive manner as the individual pan miner works for gold. The most easily worked deposits have gradually declined in productivity, and the big corporation, with costly large-scale mining equipment, has eclipsed the small-scale enterprise of the Chinese. About 60% of all Malayan tin now comes from mines owned by European interests. Huge dredges, equipped with buckets and pumps, are used to lift the tin-bearing gravels into the washing trays, and a centrifugal pump and six or eight men per shift can move as much material in 24 hours as do 500 Chinese with hand methods (see Fig. 406).

Nearly 90% of the tin ore in Malaya is derived from alluvial deposits by the use of dredges and gravel pumps. Most of the alluvial ore is obtained in the states of Perak, Selangor, and Negri Sembilan. For many years the Kinta Valley of Perak has been the most productive tin field in the world.

Alluvial deposits are usually trivial in comparison to the lodes from which they were washed. As the alluvial deposits are worked out, mining will shift to the rich lodes or veins deep in solid rock, which will be more costly, but the era of shaft-mining should last long. Most of the lode ore is mined in the state of Pahang.

After the ores have been concentrated so that they contain about 50% metal, they are shipped to huge smelters at Penang and Singapore. These smelters are owned by two British firms and produce about 40% of the world's smelted tin. They handle virtually all the tin concentrates of Malaya, most of the output of Thailand, and small tonnages of concentrates from Burma, Indonesia, and Indochina.

Tin mining in other Asiatic countries. The tin mines of Indonesia are located on the little islands of Banka, Billiton, and Singkep. A Banka smelter was dismantled during



This 4000-ton dredge makes pond and floats on it. Endless chain of steel buckets lifts mud 60 feet. Grains of tin are washed out of this mud. This "boat" needs flat, wet land. *Tin Research Institute*

World War II and has not been rebuilt. Nearly all Indonesian concentrates are now shipped to smelters in the Netherlands and the United States.

In southern Thailand the major deposits are exploited by British and Australian companies which employ modern hydraulic methods, although numerous small holdings are worked in a primitive manner by the Chinese. British firms also dominate production in Burma, where a large part of the output is derived from tin-tungsten ores mined in the Mawchi and Tavoy districts.

In China, mining occurs in the provinces of Yunnan, Kwangsi, and Hunan, and on the island of Hainan, but the great bulk of the output comes from the Kochiu district of southern Yunnan. A modern smelter has been operated by the government at Kochiu since 1932.

The tin mines of Malaya and Indonesia are producing about the same amount of tin as they did before World War II, but in Thailand, China, Burma, and Indochina today production is far below its prewar level. With the exception of Thailand, all these countries have been afflicted by disturbed political conditions in the postwar era.

The Bolivian tin industry. Bolivia is the only tin producer of importance in the entire Western Hemisphere. Its ores occur in lodes that are scattered throughout the Cordillera Real, or eastern range of the Andes. While tin is mined in about 25 districts, the Llallagua-Uncia-Huanuni district near Oruro is by far the leading producer.

The Bolivian tin industry is confronted with obstacles. The mines are located in a mountain and plateau region at an elevation of 12,000 to 18,000 feet, several hundred miles from the sea. The ores are hard and low in metal content, and they occur in thin and irregular veins, frequently at great depths. The workers are unskilled Indians, who receive a bare subsistence wage. The output per man is low.

Ores and concentrates in some areas must be carried on the backs of sure-footed burros

and llamas down tortuous mountain trails to the nearest railroad. Railway rates are high. The cost of transporting a ton of concentrates to the Pacific coast is about 6 times the cost of mining and concentrating a ton of ore.

No tin is smelted in Bolivia, for this dry and cool plateau has no coal, oil, gas, or wood. Local fuels are poor—*taquia,* or dried llama dung, *llareta,* a woody moss, and *tola,* a resinous shrub. The newly developed oil fields of eastern Bolivia may help to solve the fuel problem, but they are far away.

Bolivian tin concentrates are exported, chiefly through the Chilean port of Arica to smelters in Great Britain and the United States. They are expensive to smelt and must be blended with high-grade concentrates from Africa or Asia.

Tin means much to Bolivia.[8] It accounts for three fourths of the total value of the nation's exports. Taxes on the tin industry have yielded nearly half of the public revenue. In 1952 the Bolivian government expropriated the properties of the mining companies. The government now has the problem of operating a high-cost industry.

Tin mining in Africa. In Nigeria tin is obtained from the alluvial deposits of the Bauchi Plateau. When the mines were first opened (1911), Nigerian tin ore was carried on the backs of natives 190 miles to the navigable waters of the Benue, the eastern branch of the Niger, making a freight cost of $60 per ton to the coast. Today, however, tin concentrates are shipped by rail from the Bauchi Plateau to Lagos and Port Harcourt on the Gulf of Guinea, and thence to Great Britain for smelting.

In the Belgian Congo, tin is mined in the Katanga, Maniema, and Ruanda-Urundi districts. It is derived from both alluvial and lode deposits, and most of the output is now smelted locally prior to exportation. A direct rail route today connects the mining area with the Atlantic port of Lobito, and a good rail-and-water route extends northwestward to the port of Matadi near the mouth of the Congo River.

British domination of the tin industry. While the mining of tin now occurs in widely separated areas, the British have long exercised an almost complete control over the tin industry. This has been accomplished by political and financial control of important sources of tin, by ownership of smelting facilities, and by levying an excessive export tax on any tin destined for smelters outside of the British Empire.

In 1931, when the price of tin was dropping to unusually low levels during the world-wide depression in business, the British government secured the cooperation of the Dutch, Belgian, and other governments of important tin-producing countries to establish a cartel, known as the International Tin Committee, for the purpose of controlling production, exports, and prices. At the outbreak of World War II, 90% of the world's tin ore was produced by countries belonging to this cartel, and 87% of the world's smelting capacity was located within the British and Dutch empires. The United States had a consumer's representative on the "committee" but without the right to vote. The cartel was dissolved during the war.[9]

The position of the United States. This country is exceedingly poor in tin. Our mines, including those in Alaska, produce less than 100 tons of tin a year. We depend upon imports for about 80% of our tin supply, the remainder being derived from old scrap.

Under the pressure of wartime necessity, the U. S. government in 1942 established a 50,000-ton smelter at Texas City, Tex. It now

[8] Tin also meant much to Simón Patiño, who was born a poor *cholo,* or half-Indian, in Cochabamba. At the time of his death in 1947, his fortune was estimated at $1 billion. Patiño's mines produced about half of all Bolivian tin. At one time or another he controlled important banks, railroads, and the nation's alcohol monopoly. He had large investments in Nigerian and Malayan tin mines; he owned a huge smelter near Liverpool; and he held an interest in the National Lead Co., one of the largest U. S. consumers of tin.

[9] See Klaus E. Knorr, *Tin under Control,* Food Research Institute, Stanford University, Stanford, Calif., 1945.

produces about 20% of the world's smelted tin. It obtains more than half of its concentrates from Bolivia, the remainder being imported from Indonesia, Thailand, and the Belgian Congo.

The United States and western Europe are the big markets for tin. The former consumes about one half of the world's tin; the latter, about one third. Today the United States uses less than 1 pound of tin per capita, as compared with 1½ pounds in 1925–29. Our actual consumption of 83,500 long tons in 1953 was less than in 1925. Technological improvements, such as electrolytic tin plating instead of hot-dip method, make possible more end-products from a ton of metal.

Tin is a highly strategic metal. Not a single battleship, airplane, tank, truck, or cannon could be built without tin. Armies and navies are fed out of tin cans. Our dependence upon distant sources of tin makes a large stockpile essential to national defense.

5. NICKEL

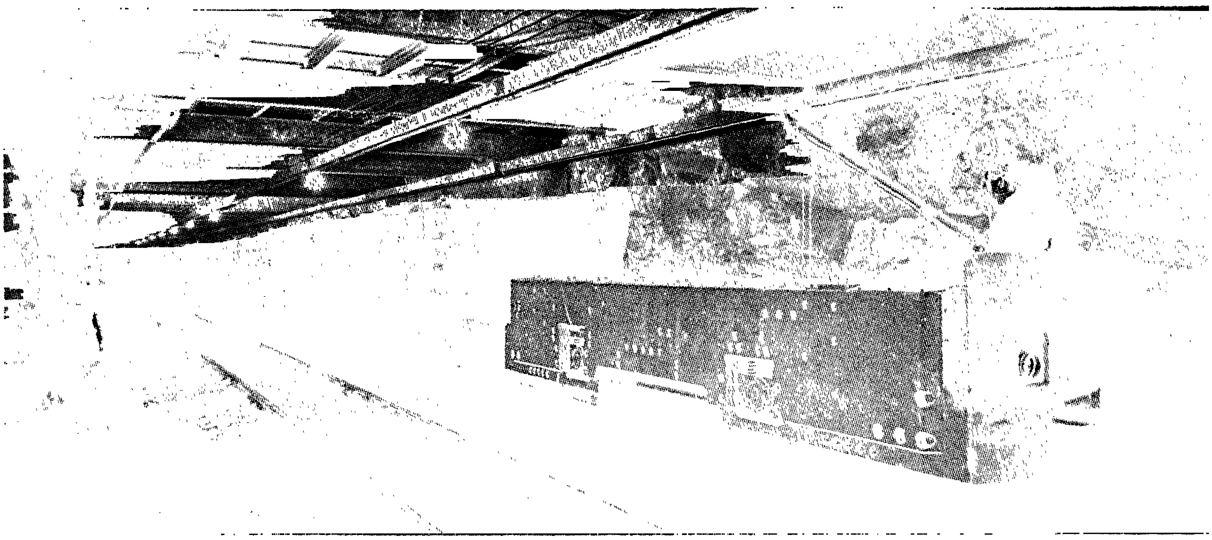
The changing demand. Although nickel has been mined and used in small quantities for more than 2000 years, its rise as an important industrial metal has been comparatively recent. As late as 1885 the world consumed only 750 tons of nickel, which was used chiefly in coins and nickel silver. In the 1890's demand for the metal increased as nickel came to be used in galvanizing iron, in electroplating, and especially as a steel-making alloy in the manufacture of armor plate for battleships. About this time the world's available supply was greatly enlarged by the perfection of a process in 1893 that permitted the recovery of nickel from the copper-nickel ores of the Sudbury district in Ontario.

It was very largely the demand for nickel steel in the production of armaments that caused the world's nickel output to increase from 3000 tons in 1890 to 35,000 tons in 1913, and to 52,000 tons in 1918. This demand almost vanished during the 1920's, when disarmament programs were in vogue, but the growth of the automobile, construction, and other industries created new markets for nickel and its alloys. Indeed, in 1929 about 90% of all nickel was used for commercial purposes, whereas in 1913 about 90% had been consumed in armament manufacture. In the late 1930's nickel again went to war, production reaching an all-time peak of 184,000 short tons in 1943.

A great alloy. Nickel is commonly used as a surface coating for bathroom fixtures and other familiar objects; it performs valuable service as a catalytic or chemical reagent; and it is used in storage batteries and for a great variety of purposes. But the oustanding fact about the consumption of nickel is that more than four fifths of the world's supply is employed in the manufacture of alloys.

Nickel has great tensile strength; it resists corrosion and the action of most acids; it melts at 2646°F.; and its electrical conductivity is only 15% that of copper. These qualities are imparted to alloys by the metallurgist, a wizard who is able to meet the diverse needs of industry by skillfully adjusting the proportion of nickel to be used in conjunction with other metals. Thus, white gold in jewelry has a nickel content of 15%; rose gold, 5% to 6%; and green gold, 1% to 2%.

Nickel is extensively used in the manufacture of structural steel, a product that must have great tensile strength, the nickel content varying with the requirements of the finished products. Heat-resistant steels contain 7% to 35% nickel and are especially useful in making equipment for the ceramic, glass, metal, and oil-refining industries and for use wherever high-temperature chemical processes are employed. In the manufacture of stainless steel, about 8% nickel and 18% chromium are alloyed with low-carbon steel, the resulting product being highly resistant to corrosion. Likewise, Monel metal, an alloy chiefly of nickel and copper with a nickel content of 68%, resists corrosion and the action of most acids; hence, it is commonly used in making marine shafts and propellers and many kinds of equipment for kitchens, canneries, hospitals, laundries, and chemical laboratories. Our



Subway in solid rock—120 miles of it in one copper-nickel mine at Sudbury, Ontario—13 million tons of ore taken up each year. This mine also yields copper. *International Nickel Co.*

ubiquitous 5-cent piece, commonly known as a "nickel," is a copper-nickel alloy containing less than 25% nickel.

Most nickel is used in conjunction with iron and copper. In the United States about 40% of all nickel is consumed in the manufacture of steel, about half of which is stainless steel. About 30% is used in making copper-nickel alloys, nickel-silver, Monel metal, magnesium and aluminum alloys, and other nonferrous alloys. Other major uses are electroplating, high-temperature and electrical-resistant alloys, and nickel cast iron.

The predominance of Canada in nickel production. About 70% of the world's nickel is mined in the Sudbury district of southern Ontario, Canada. This little district, about 36 miles long and 16 miles wide, has proved reserves of nearly 253 million tons of nickel-copper ore containing more that 7½ million tons of metal. All but 15 million tons of the ore is owned by the International Nickel Co. of Canada, Ltd. The deposits are worked by modern open-pit and shaft-mining methods. They have the outstanding advantage of being near the U. S. market, which consumes about two thirds of the world's nickel.

At Lynn Lake in northern Manitoba the Sherritt Gordon Mines, Ltd., is developing a deposit of nickel-copper ore estimated at 14 million tons. Commercial production at Lynn Lake awaits the construction of a railroad. In 1953 the International Nickel Co. announced the discovery of a new deposit at Mystery Lake, about 420 miles north of Winnipeg, that may eventually rival Sudbury. In 1953 Canada produced 143,000 short tons of nickel and exported 98% of it.

The Soviet Union, unlike Canada has an annual output of about 27,000 tons, or barely enough to meet its needs. Nickel is now mined and smelted at Pechenga (Petsamo) along the Barents Sea, at Monchegorsk on the Kola Peninsula, at Orsk near the southern end of the Urals, and at Norilsk in the lower Yenisei valley.

New Caledonia led the world in nickel production from 1875 until 1903, when it was surpassed by the Sudbury district. Nickel ores on the island occur in small, scattered, surface deposits that are not amenable to large-scale operations, nearly all the mining and sorting of ore being performed by manual labor. The mines are owned by La Société de Nickel. The ores are smelted locally with Australian coal, and the nickel matte is exported to Le Havre, France, for refining. New Caledonia produces about 12,000 tons of nickel a year.

The United States is as poor in nickel as it is in tin. It recovers less than 5000 tons of

nickel annually from old scrap, and it produces less than 700 tons of primary nickel, chiefly as a by-product of copper refinishing. We depend upon Canada for nickel.

Domination of industry by one company. The nickel industry and the International Nickel Co. are almost synonymous. In addition to its mines and concentrating mills, this company owns a smelter at Coniston and a smelter and refinery at Copper Cliff in the Sudbury district; electrolytic refineries at Port Colborne, Ont., and Clydach, Wales; a plant at Acton, England, for recovering precious metals from the slimy residue of the refining process; and fabricating plants at Huntington, W. Va., Bayonne, N. J., Birmingham, England, and Glasgow, Scotland.

The International Nickel Co. produces 10 times as much nickel as its only Canadian competitor, the Falconbridge Nickel Mines, Ltd., which operates mines and smelters in the Sudbury district and which ships matte to its electrolytic refinery at Kristiansand, Norway, where Norwegian nickel is also treated. Neither this firm nor the French company in New Caledonia offers any serious competition to the International Nickel Co.[10] From the viewpoint of applied geography, there is really only one mining district and one business enterprise of significance in the nickel industry.

6. LEAD

The antiquity of lead. Man's first use of lead lies in the unknown prehistoric past, but it is certain that the ancients made common use of the metal. Lead is mentioned several times in the Old Testament.[11]

In Roman times the imperial water bureau not only provided the great aqueducts of Rome but also laid down lead pipes for the distribution of water to the imperial palaces, to public baths and gardens, and to a large number of public fountains whence the poor carried their water.[12] In those days the plumber was a manufacturer of lead, slaves being employed as workers in the lead-making shops and in laying and repairing pipes. Our modern word *plumber* is derived from the Latin *plumbum,* meaning lead, and the irate householder of today, when in urgent need of repairs, may think that the plumber is laden with the heavy metal as he slowly returns to his shop to fetch his tools.

Properties and uses. Lead is a soft, heavy metal that melts at 621°F.; it is extremely malleable, unusually resistant to corrosion and and the action of most acids, and easily alloyed with many metals; and it is a poor conductor of electricity. These qualities, together with its cheapness, have made it one of the most versatile of all metals.

In the United States about 30% of all lead is used in making storage batteries. Approximately 30% is used in the manufacture of coverings for telephone, telegraph, and other electric cables, in the manufacture of tetraethyl lead used in high-octane gasoline, and in white and red lead that are needed for making paint. Other important uses include the manufacture of ammunition, solder, bearings, and printers' type, and for calking ships. Lead has long been an ingredient in ammunition, and a war without lead would be a bulletless war.

Occurrence and production. Lead is a gregarious sort of metal that is almost always found in the company of other metals. Most lead ores contain both silver and zinc, but in widely varying ratios, and are associated with other metals that may occur in minute or important quantities, such as copper, gold, antimony, molybdenum, vanadium, cadmium, bismuth, and arsenic. Such is the case of the

[10] See William Y. Elliott and others, *International Control in the Non-Ferrous Metals,* The Macmillan Co., New York, 1937, pp. 109–209, and "The Squeeze on Nickel," *Fortune,* November 1950, pp. 93–96 ff.

[11] See *Exodus* 15:10, *Numbers* 31:22, *Job* 19:24, and *Ezekiel* 27:12.

[12] The wealthy citizen, desiring water in his home, had to purchase pipe and pay to have it laid from the public water main to his home, often involving considerable distances. In order to protect his ownership, he had his name stamped on each piece of pipe. Tenney Frank, *An Economic History of Rome,* The Johns Hopkins Press, Baltimore, 1927, pp. 239–241.

most of the world's famous lead deposits, including those of San Luis Potosí and Chihuahua in Mexico, Broken Hill and Mount Isa in Australia, and Cerro de Pasco in Peru.

In certain areas lead and tin are found together, as in Cornwall, Bolivia, and Tasmania. In other areas lead ores contain silver but no zinc, as in the Linares-Carolina lodes of Spain which have been worked since before the Christian era. On the other hand, the Silesian ores of Poland and Germany, the Santander ores of Spain, and the Monteponi ores of Sardinia contain no silver. Southeastern Missouri is our leading producer of lead, its ores containing almost no silver or zinc, while those of the Rocky Mountain states are generally high in silver content and are often associated with copper, gold, and other metals. Therefore, it is clear that the prosperity of the lead-mining industry depends not upon its own conditions of supply and demand but also upon those of silver, zinc, and other metals that are produced in conjunction with lead.

In response to the growing demand for lead and for the metals associated with it, the world's output of lead has increased from 408,000 short tons in 1880 to 1,269,000 tons in 1913, and to 1,983,000 tons in 1953. Although lead-bearing ores are mined in some 35 countries, the United States, Australia, Mexico, the Soviet Union, and Canada produce about three fifths of the world's lead supply. Each of these leading nations is also a great producer of silver and zinc.

As ores of silver-lead-zinc deposits tend to occur in zones, many a mine has begun operations as a silver mine with lead as a by-product. As the shafts have deepened, it has become a lead mine with silver as an important by-product.

In general, concentration and smelting of lead ores occur within the mining districts. The widespread adoption of the selective flotation process has lowered the cost of reducing complex ores and has brought about a more effective recovery of lead and the valuable metals that are mined with it.

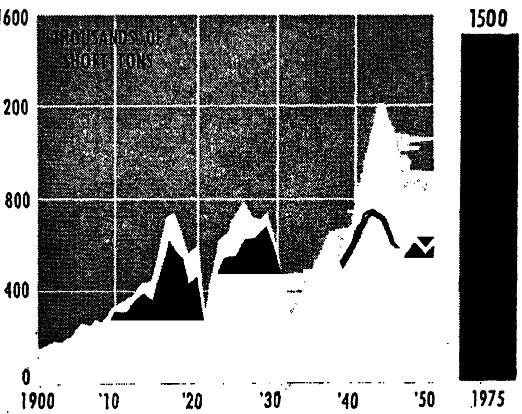
In recent years scrap metal has become an increasingly important source of lead. More than half of the secondary lead produced in the United States each year is derived from discarded storage batteries, and much metal is obtained from old cable coverings, pipes, printers' type, and bearing metal. The collection and smelting of scrap is now a well-organized industry, and the methods of recovering the metal from scrap materials have been greatly improved.

7. ZINC

Man's ally against corrosion. Is seems to be Nature's intention to keep the metals, with few exceptions, in a state of corrosion. Man, with great stubbornness, is determined to prevent this from happening; yet in spite of his efforts about 15% to 20% of all iron is eventually lost through rusting. In the battle against corrosion, one of man's greatest allies is zinc, which is used in galvanizing iron and steel.

When a product is galvanized, zinc makes a smooth, protective covering that adheres tightly to the iron or steel base, since it forms an iron-zinc alloy at the surface contact. If the iron and zinc are exposed to weather, so long as the two metals remain in contact, the zinc is oxidized first. Hence, zinc affords the protection of a Swiss Guard, for when the coating is broken, the zinc holds out as long as possible and perishes to the last atom before it lets oxygen at the iron.[13] The durability of a galvanized product, of course, depends upon the thickness of the zinc coating. Among the many products that are galvanized today are fences, posts, wire, cable, building roofs, culverts, tanks, pipes, pans, and pails. About 40% of all zinc consumed in the United States each year is used in galvanizing iron and steel.

[13] This is known as the "sacrificial action" of zinc. While zinc is negative toward iron, tin is positive. Hence, when a tin can or other plated object is scratched deeply, the iron beneath rusts more rapidly than if the tin were not there, for an electrolytic action is set up, and the iron suffers at the expense of the tin.



Zinc. White is production; black is consumption. Independent? *President's Material Policy Committee, Resources for Freedom, Vol. I, p. 22.*

Other uses. Approximately 20% of all zinc is used in die castings, such as automobile parts, and 18% is consumed in pigments and salts used in the manufacture of rubber, paint, and pharmaceuticals. Only 10% is used in making brass. Much of the remainder is used in the manufacture of rolled zinc, which is needed to make dry battery cans, engraver's plates, and brake linings for automobiles.

The U. S. zinc industry. For decades the United States has been the world's leading producer and consumer of zinc, but decline has set in. In 1953 we dug only 20% of the world's supply. The quality of U. S. ores is generally low, averaging 5% in zinc content as compared with 13% for the rest of the world.

More than half of all zinc in this country is mined in five districts: (1) Coeur d'Alene, Ida., which leads in silver and ranks second in lead production; (2) the Tri-State district of eastern Oklahoma and Kansas and southwestern Missouri, centering around Picher, Okla.; (3) Butte, Mont., where zinc production fluctuates with that of copper; (4) Franklin, N. J., where zinc ores average 19% in metal content; and (5) St. Lawrence County, N. Y. The tri-state district was the world's most prolific zinc producer from 1915 until 1950, when it was surpassed by Coeur d'Alene.

In recent years about 60% of our zinc production has been obtained from domestic ores, 34% from foreign ores, and only 6% from scrap. Zinc cannot be recovered from old galvanized products or from pigments used in paints, and only small amounts are obtained from die castings and rolled zinc products. In contrast with iron, copper, lead, aluminum, and many other metals, zinc is an especially wasting asset.

Foreign production. In 1953 five nations accounted for 59% of the world's newly mined zinc, namely, the United States, Canada, the Soviet Union, Australia, and Mexico. Other producers of importance are Peru, the Belgian Congo, Italy, West Germany, and Spain.

Three fourths of all Canadian zinc is mined in the Kimberley district of British Columbia, most of the remainder being produced near Flin Flon, Manitoba. In Mexico zinc has long been mined in San Luis Potosí, Zacatecas, Chihuahua, and other states. Australian zinc mining occurs chiefly in the Broken Hill and Mt. Isa districts of New South Wales. In the Soviet Union three fourths of all zinc is mined near Leninogorsk (Ridder) in the Altai Mountains of Kazakhstan, the remainder being produced in such widely scattered districts as the Caucasus, Urals, Lake Balkhash, and Vladivostok.

Canada, Mexico, and Australia have large surpluses for export, Soviet ores being consumed entirely at home. Canada exports most of its output as refined metal to Great Britain and the United States. Mexico ships zinc concentrates to the United States, Belgium, and France. Most of the Australian output is exported to Great Britain and Belgium for smelting and refining, although an increasing amount of refined zinc is being shipped to Great Britain, India, and Japan.

While the crushing and concentration of ore occurs within mining areas, the great bulk of the world's zinc is smelted and refined in or near great markets where fuel and skilled labor are available. The United States, Canada, the Soviet Union, Belgium, and West Germany account for 70% of the world's output of slab zinc.

However, the advent of electrolytic beneficiation has permitted the production of refined zinc in or near mining areas that have cheap electric power, as in Canada and our western states of Idaho and Montana. The electrolytic zinc refineries at Great Falls, Mont., and Trail, British Columbia, are the largest in the world.

Zinc production and the future. With the advent of the selective flotation process, the recovery of zinc from ore increased from 30% to over 80%. By 1925 it was evident that the world's available zinc reserves had been at least doubled by this process, which also enables the economic recovery of silver, lead, copper, gold, and other metals frequently associated with zinc. The world's zinc output increased from 1.1 million short tons in 1913 to 1.3 millions in 1925, 1.8 millions in 1939, and to an all-time peak of 2.7 millions in 1953.

Unlike lead, the zinc outlook for the next quarter of a century is expected to meet growing demand with little or no increase in costs. There are more zinc deposits containing little or no lead than there are lead deposits with no zinc. In typical complex ores the zinc content usually exceeds the lead content in the ration of 2 to 1. Zinc production can be expanded considerably in Canada, Peru, the Belgian Congo, Italy, Southwest Africa, and Japan. A developmental boom is under way, and new zinc-mining districts are expected to become important producers, such as the Zellidja area in Morocco and Algeria.[14]

8. GOLD

The nonindustrial use of gold. Because of their remarkable malleability, durability, beauty, and comparative scarcity, gold and silver were highly prized for ornaments and coins even before the dawn of recorded history. The durability of gold and the human desire to keep it are well shown by the fact that gold mined before Caesar was born is a part of the great hoard that now lies in the vaults of the United States government.

For many centuries the prime function of gold has been to serve as money, a medium of exchange and standard of value that proved to be universally acceptable.[15] Most of the world's gold is now locked up in monetary reserves. In normal times about one fourth of the world's output of gold is used in jewelry, dentistry, chemistry, the arts, and for other purposes. Plainly gold is not one of the world's great industrial metals.

Mining methods. Widely scattered in the earth's crust, gold is collected into veins of quartz in many kinds of rock. The destruction of exposed veins in the wearing down of mountains by streams has caused the transportation of gold along the courses of streams to great distances from the original veins. Sometimes the search for gold along these streams leads back to the vein, or mother lode, from which the stream supply has been eroded.

There are two main types of gold mines—placers and lodes. Placers are those in which gold is recovered from sand and gravel in the form of native metal or natural alloy. Lode mines are those which yield gold from original veins of ore, chiefly from underground workings.

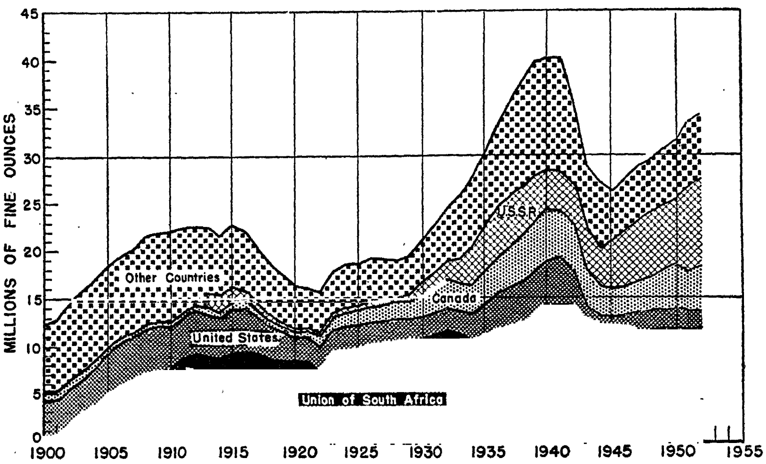
The individual prospector, seeking nuggets and grains of gold in stream beds, uses a pan in which sand and water are agitated until the heavy gold settles to the bottom. This is the simplest form of placer mining.

Large banks of sand and gravel may be worked by hydraulic mining, which consists of washing down the gravel banks by the force of a stream of water from a nozzle. The water carries the sand through long sluice boxes, with crevices in the bottom, in which the gold is caught, because, being the heaviest of the materials, it gradually settles to the bottom.

Except for such small-scale methods as the

[14] See The President's Materials Policy Commission, *op. cit.*, p. 48.

[15] Gold has qualities that have long made it an ideal money commodity, namely, its durability, great value in small bulk, uniform quality, fusibility, cognizability, and general acceptability. Since gold is soft, it must be alloyed with harder metals to make coins that will wear. Since the abandonment of the gold standard in the early 1930's we have come to live in an era of "managed currency," yet many authorities believe that gold is the best medium of exchange that the world has ever known.



Gold. **U. S. declines. Soviet rises. Canada takes a part.** ***U. S. Bureau of Mines***

use of the miner's pan, all placer mining involves the use of sluice boxes. Gravel may be delivered to the sluices by power shovel, dragline excavator, slack-line scraper, and other mechanical means, or—if labor is cheap—by men equipped with shovels.

Dredging is by far the most important form of placer mining today. The single-dipper dredge, dumping big bites of gravel into sluices aboard the dredge, has been eclipsed by the giant dredge equipped with a continuously moving line of buckets. Fully four fifths of all placer gold in the United States is recovered by bucket-line dredges.

Lode mines are the most permanent sources of gold. Most of them are worked by shaft-mining methods. The ore is usually ground fine by a stamp mill, and then washed by a process similar to that pursued in placer mining. Since washing does not get out all the gold, the pulverized ore may be treated with mercury or with a potassium-cyanide solution in order to recover all the gold. The selective froth-flotation process is used to treat complex ore containing gold in combination with silver, copper, lead, zinc, and other metals. Modern technology in a few instances has made it profitable to extract gold metal no larger than two pinheads from a ton of simple ore.

Modern technology goes far to explain the great increase in gold production in the last 60 years. The world's output of gold more than tripled between 1892 and 1912 and then almost doubled again between 1912 and 1940, when it reached an all-time peak of 42 million fine ounces. Production now amounts to about 34 million fine ounces a year, as compared with an average of 38 millions in 1937–39.

The uncertainty of production. Few industries have less permanence in any given locality than gold mining. It may be likened to a fever because of its sudden great activity, its decline, and its intermittent revivals. Rumors of gold discovery start a "rush" of miners from all parts of the world. In the desire to stake out a good claim, it matters not if they must penetrate thick forest, hot desert, or arctic waste. The California Gold Rush of 1849 and the human stampedes to Australia in 1851, the Fraser River Valley of Canada in 1858, the South African Rand in 1886, and the Klondike in 1897 are well known to every student of history.

In almost every case the gold in stream beds is soon exhausted. Then come the dredges and other mechanical means of surface mining. Finally, the mother lode is discovered, and as the shafts penetrate deeper into the earth, the cost of mining increases. A gold-mining district may keep on producing for years, decades, or even centuries, but decline and exhaustion are its ultimate fate.

The pre-eminence of South Africa. Four fifths of the world's gold is now produced by four nations—the Union of South Africa, the Soviet Union, Canada, and the United States. The mines of South Africa alone account for more than a third of the world's output.

South African gold mining is concentrated in the Witwatersrand, commonly called the

Rand. This district, about 50 miles long and 20 miles wide, surrounds Johannesburg, the capital of the Transvaal. To obtain 425 tons of gold during an average year, approximately 67 million tons of ore must be raised to the surface of the earth.[16] Some of the mines are 9000 feet deep.

The Union of South Africa has led the world in gold production since 1905, and apparently it will continue to be the twentieth century's kingdom of gold. A new gold field is being developed at Odendalsrust in the Orange Free State about 150 miles south of Johannesburg. Exploratory drilling indicates that this field may eventually rival the famous Rand, which has produced more than $16 billion worth of gold to date.[17]

Gold in the Soviet Union and Canada. The Soviet Union has ranked second in gold production since 1934, and its mines now yield more than one fourth of the world's gold. The chief mining districts are in the upper Kolyma and Aldan river basins of northeastern Siberia, where large placer deposits are worked with modern methods. The principal lode deposits lie to the east of Lake Baikal. Other gold-mining districts are scattered throughout Siberia, the Urals, and the Caucasus.

In Canada gold production is concentrated largely in the Porcupine, Kirkland, and Larder Lake districts of eastern Ontario and the adjacent area of Quebec. About 97% of the dominion's gold comes from lodes, 85% being obtained from gold-bearing quartz veins, and the remainder being derived from ores containing gold in association with copper, nickel, zinc, and other metals.

The white band is a quartz vein containing gold. The tunnel follows the vein. ***Union of South Africa***

[16] Erich W. Zimmermann, *World Resources and Industries,* rev. ed., Harper & Brothers, New York, 1951, p. 761.

[17] The native people of Africa, and perhaps also the whites who are there, have been cursed by gold and diamonds, and copper may duplicate this human woe. The Dutch and British elements of the white population do not get along too well together. The 2.6 millions of European stock in the Union of South Africa are determined to govern the 10 million non-Europeans, take most of their land, and have them work the mines at low wages. The non-Europeans are 8.5 million Bantus, 1.4 million "coloured," and .4 million Asiatics, mostly Hindus.

The lure of glistening gold and glittering diamonds in almost limitless quantity has supplied the foreign corporation with hundreds of millions of money, equipped it with plenty of machines, technical skill, barbed wire, and profits. This industrial meteor, falling into the midst of primitive, illiterate, almost helpless millions of tribesmen has produced one of Western civilization's sad blots. If interested in reading about human relations, the publishers' lists and magazine indexes will give you plenty. See "Africa's Modern Slavery," *Harpers Magazine,* July 1954.

Explosions appear to be in the making. Arnold J. Toynbee puts it thus: "Communism is politically formidable to us Westerners today because it is politically attractive to anyone who is being treated as a 'native.' Any human being will revolt against being treated as a 'native.' For the millions who are still being treated as 'natives' today, communism is an obvious remedy, because they have come to know that, if they go Communist, they will not be treated as 'natives' any longer." From: "The Revolution We Are Living Through." *The New York Times Magazine,* July 25, 1954, p. 44.

Vast areas in Canada's great northern forest remain relatively unsurveyed. For years travel in this region was confined to the snowshoe, dog sled, and birch bark canoe. Today the prospector flies in. When gold is struck in some remote locality, men and equipment are flown in at once by airplane. In the wintertime thousands of tons of machinery are moved in trains of sleds, which are pulled by tractors across the frozen hills, rivers, and lakes, especially rivers and lakes.

Gold in the United States, Australia, and other lands. The United States led the world in gold production throughout most of the latter half of the nineteenth century, but our mines now yield only 6% of the world's gold—a suggestive fact. From the mines of California has come about 40% of all the gold that has been mined under the American flag to date. At the present time South Dakota, Utah, California, and Alaska are our leading producers, their combined output amounting to more than 70% of the nation's newly mined gold.

In South Dakota gold is obtained from siliceous gold ore in the Whitewood district of the Black Hills. Utah's gold is largely a by-product of copper ore that is mined at Bingham. In California gold is recovered from the gravels of the Folsom, Yuba River, and Oroville districts and also from the ores of the Grass Valley-Nevada City and Mother Lode districts. In Alaska the lodes at Juneau and Willow Creek have declined, and gold is obtained almost entirely from gravel deposits, chiefly in the Fairbanks, Nome, and Tuluksak-Aniak areas.

Australia ranks fifth in gold production with an output of about 1 million fine ounces a year, or about half as much gold as is mined in the United States. Three fourths of all gold is mined from lodes in western Australia. The "Golden Mile" at Kalgoorlie is probably the best-known mining district, although Kimberley, Coolgardie, and other places became famous. So great has been the imprint of gold mining upon the nation's history that Australians often hail each other as "Digger," in spite of the fact that Australia is no longer pre-eminent in the gold-mining industry.

Other producers of lesser importance are the Gold Coast, Southern Rhodesia, Mexico, and Colombia. During the sixteenth, seventeenth, and eighteenth centuries Latin America's share of the world's gold production increased from 40% to over 80%. Today all the nations south of the Rio Grande account for less than 5%. Such is the fleeting fame of gold.

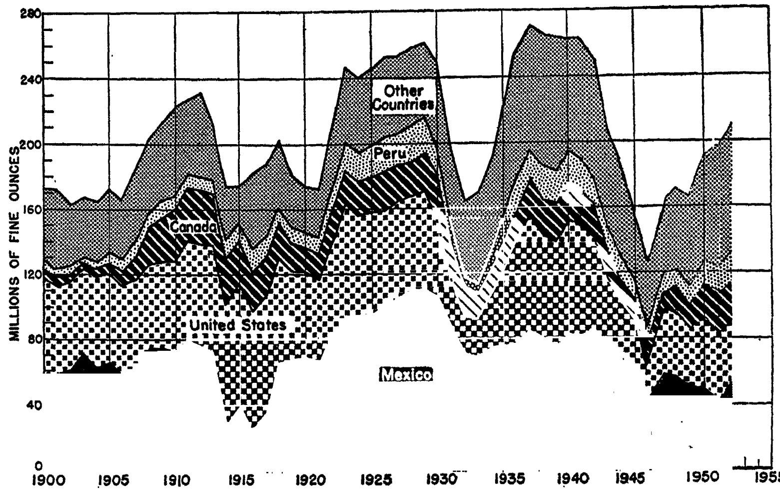
9. SILVER

A by-product metal. In contrast with most other commodities, the production of silver does not respond readily to an increase or decrease in its price, because fully three fourths of the world's silver is mined in conjunction with copper, lead, zinc, and other metals. Most of the silver that is mined today is distinctly a by-product of complex ores that owe 50% or more of their value to other metals found in these ores. As industrial activity expands, the demand for copper, lead, and other base metals increases, thereby increasing the production of silver.

Between 1880 and 1940 the world's output of silver increased from 78 to 273 million fine ounces. Since World War II, it has amounted to less than 200 million fine ounces a year.

Mexico: the leading silver producer. More than 80% of the world's silver is produced by five nations—Mexico, the United States, Canada, Peru, and Australia. Mexico has long led the world in production and now accounts for 25% to 30% of the world's output. In contrast with the other leading nations, where silver is predominantly a by-product metal, most Mexican silver is derived from silver ores.

The greatest silver mines in Mexico are those of Pachuca, which have been worked for centuries and now yield most of the silver produced in the state of Hidalgo. Other important silver mines are located near the towns of Chihuahua, San Francisco del Oro, Parral, and Santa Barbara in the state of Chihuahua, at Fresnillo and Mazpil in Zacatecas, and at Sierra Mojada in Coahuila. The states of



Silver. Mexico, great leader, declines. Silver declines in depression and war. *U. S. Bureau of Mines*

Hidalgo, Chihuahua, and Zacatecas produce more than two thirds of the nation's silver.

The large mines use modern machinery and methods. In the smaller and more primitive mining areas an ancient device is still used—the *arrastra,* a stone floor on which ore is crushed by a stone wheel that is rolled around upon the ore by beasts of burden. From the crushed ore the silver collects in the cracks of the stone floor and in this concentrated form is carried scores or even hundreds of miles on pack mules.

The United States silver-mining industry. The United States produces about one fourth of the world's silver. Idaho, Montana, Utah, and Arizona account for nearly 85% of our supply. Actually three districts produce nearly two thirds of the nation's silver—Coeur d'Alene, Ida., Butte, Mont., and Bingham, Utah.

Only 5 of the 25 leading silver-producing mines in this country are operated for silver alone. American silver is predominantly by-product silver, and its prosperity is tied to the apron strings of copper, lead, zinc, and gold. Anaconda, Kennecott, and Phelps Dodge are not only great names in copper, but they rank high in the silver-mining world.

Silver mining in Canada, Peru, and Australia. Canada, the third leading producer, gets more than 40% of its silver from British Columbia and most of the remainder from Ontario and Quebec. The great Sullivan mine at Kimberley, British Columbia, is the dominion's largest producer of silver, lead, and zinc. The complex ores of the Sudbury and Cobalt districts in Ontario, the Noranda-Rouyn district of western Quebec, and the Flin Flon area of Manitoba and Saskatchewan are also important sources of silver.

Peru continues to produce more than half of all the silver in South America. The greatest mining district lies at an elevation of 14,700 feet at Cerro de Pasco, and the mines, which have been worked for more than 300 years, yield most of the nation's silver, copper, and gold.

Most Australian silver is mined in the Broken Hill district of western New South Wales, which is also famous for its zinc and lead, and much of the remainder of the country's silver comes from the Mount Isa district near Cloncurry, Queensland. Other silver-mining countries of lesser importance are the Soviet Union, Bolivia, the Belgian Congo, and Japan.

Industrial importance. Silver is more abundant and cheaper than gold, and its industrial uses are more numerous and varied. Between 1901 and 1953 the net industrial consumption of silver in the United States increased from 13 to 105 million fine ounces. Between 40 and 50 million fine ounces of the metal are used each year in the manufacture of sterling silverware, which has long been the principal industrial use of silver.

Other important markets for silver include the photographic industry, the electroplating industry, the manufacture of jewelry, optical goods, and novelties, and the production of silver-lined steel tanks and other equipment for the chemical industry. During World War II much greater use was made of silver in the production of solder and brazing alloys, and it often replaced nickel and chromium for metal plating and much tin in Babbitt metal.

In spite of the growing industrial uses of silver, much of it is used for monetary reserves and subsidiary coins. Scarcely a year goes by without some representative of the silver industry publicly advocating either the unlimited coinage of the metal or that the United States government should increase its purchases of silver. The silver industry has never lacked special pleaders in this country and in other silver-producing nations.

10. PLATINUM

Properties and uses. For centuries man has regarded silver and gold as the precious metals. In recent times platinum has been far more valuable. In 1953 the average market price of silver in New York was 85¢ per fine ounce, the United States treasury paid $35 per fine ounce for gold, whereas platinum sold for $91.24.

Platinum is heavier and more ductile than copper, silver, or gold; it has a high melting point (3190°F.) and a tensile strength of 42,000 pounds per square inch; it resists the action of alkalies and most acids; and it is a good conductor of electricity.

The chemical industry provides the chief market for platinum, utilizing the metal in the manufacture of sulfuric and nitric acids, as a catalyst in producing high-octane gasoline from low-grade and natural gasoline, and for many other purposes. Of 276,580 troy ounces of platinum metals sold in the United States in 1953, about 58% was used by the chemical industry, 24½% by the electrical industry, 11½% by the jewelry trade, 5% by the dental and medical professions, and 1% for miscellaneous purposes.[18]

Closely allied with platinum are other platinum metals, namely, palladium, iridium, rhodium, ruthenium, and osmium. These are generally similar to platinum but have particular qualities that enable them to serve in specialized uses. Thus rhodium has been called "the diamond of metals," for it is one of the whitest and hardest of all metals and never tarnishes; hence, rhodium plating is used for surfacing reflectors in powerful searchlights and as a finish for jewelry and silverware. Iridium and osmium, because of their hardness and resistance to corrosion by ink, are used in the manufacture of points for higher-priced fountain pens. However, the most widely used metal in the group is platinum itself, which accounts for over one half of the consumption of all platinum metals.

Platinum production. The world's output of platinum amounts to over 500,000 troy ounces a year. In 1952 about 43% was mined in the Union of South Africa, 23% in Canada, 20% in the Soviet Union, and nearly all of the remainder in Alaska and Colombia. The United States is poor in platinum and imports the bulk of its supply.

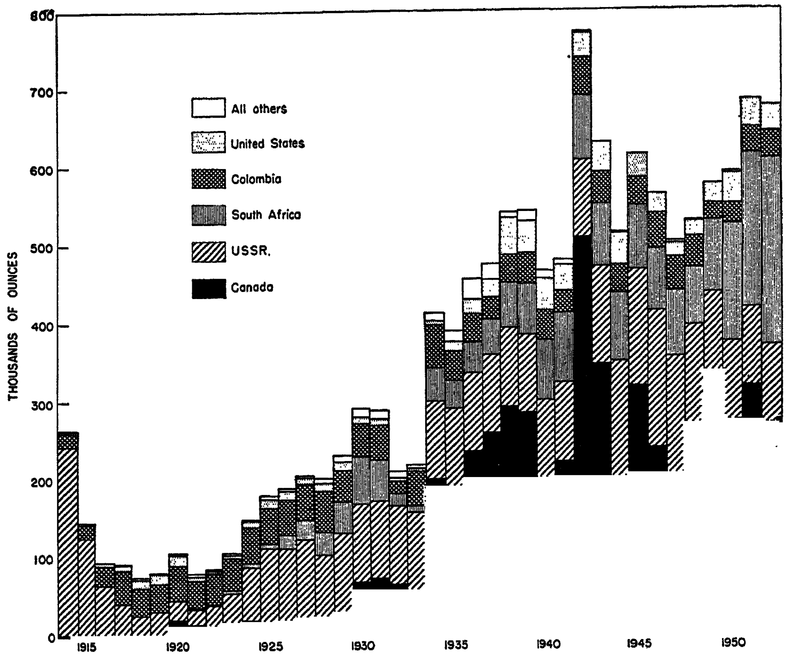
Canada led the world in platinum production from 1934 until 1952, when it was surpassed by the Union of South Africa. Canadian platinum is a by-product of the nickel-copper ores at Sudbury. South African production is concentrated in the Rustenburg district of the Transvaal, which is endowed with one of the world's largest reserves of platinum ore. In the Soviet Union platinum is obtained chiefly from large placer deposits at Nizhni Tagil in the Urals. The placers of the Choco district in Colombia and of the Goodnews Bay area in Alaska are of minor importance.

11. DIAMONDS

Prime functions: adornment and abrasion. Precious stones are minerals that are desired for purposes of adornment because of their beauty, durability, and scarcity. For centuries the brilliance and sparkle of a skillfully cut diamond have made it the most valued of all

[18] American Bureau of Metal Statistics, *op. cit.*, p. 108.

Platinum. U. S. has but little of this very precious metal. See mining booms in Canada and Africa. *U. S. Bureau of Mines*



precious stones. The connection between love and diamonds is nebulous, but there is a definite relationship between the number of marriages and the volume of diamond sales. Most engagement rings are bought in December, not June, making it possible for thrifty couples to celebrate both Christmas and impending marriage with one stone.

Because of its extreme hardness, the diamond is very useful as an abrasive material. Small diamonds, stones of imperfect structure and dull color, and diamond dust are used in the manufacture of grinding wheels, rock drills, dies, and glass-cutting tools. Industrial diamonds account for two thirds of the world's diamond output by weight, but gem diamonds account for three fourths of the value.

Diamond mining. As late as 1700 India was virtually the sole source of diamonds, and production was steadily decreasing. In 1721 diamonds were discovered in the stream beds of the Brazilian state of Minas Gerais. The supply proved to be large, and Brazil maintained leadership in diamond production until surpassed by South Africa in 1872. Today the Brazilian output is small, consisting of small gems and black industrial diamonds that are recovered from the gravels of Minas Gerais and Bahia.

In 1867 alluvial diamonds were discovered in South Africa. Three years later the first diamond "pipe" was found near Kimberley in the Transvaal, a rich lode that is now being worked at a depth of more than 3000 feet. Such pipes consist of diamond-bearing rock that has been embedded in volcanic material. After the diamond-bearing rock has been mined, it is crushed, washed in pans, concentrated in jigs, separated on grease tables, and carefully graded by sorters. To prevent theft, native workmen are kept on the mine premises almost like prisoners during the term of their labor contract.

About seven eighths of the South African diamond output comes from pipes, located between Jagersfontein in the Orange Free State and Pretoria in the Transvaal. The remainder is obtained from widely scattered gravel deposits. As in gold mining, gravels give way to lodes.

The major diamond fields discovered and developed during the present century are the Buwanga field of the upper Kasai River Valley in the Belgian Congo, the Diamang field of northeastern Angola, the Birrim Valley district of the Gold Coast, and the Kenja and Kono fields of Sierra Leone.

The world's diamond output now amounts

to about 15 million metric carats a year. Two thirds of the world's diamonds, on the basis of weight, are produced in the Belgian Congo, the Union of South Africa ranking second with 11%. However, only about 5% of the Belgian Congo production is of gem quality. The Union of South Africa leads in value of output, owing to its high percentage of gem stones.

The discovery of huge diamonds is spectacular but exceedingly rare. In 1905 a foreman in the Premier mine near Pretoria found the world's largest diamond, known as the Cullinan diamond, which weighed 3106 carats, or 1⅓ pounds. The 726-carat Vargas diamond was found in Brazil in 1941. It was subsequently cut into 23 gems, the largest weighing 21.6 carats. In 1951 a diamond weighing 511 carats was found near Kimberley. The owner sold it for $51,000, and the Negro worker who found it received $280.

Diamond cutting. The diamond is a prism and has a high refractive index that causes it to split the white light of the sun into all the colors of the spectrum, but its brilliance and sparkle, so desirable in jewelry, depend largely upon the skill with which the diamond is cut. Centuries ago Hindu lapidaries in India learned to cut diamonds by the use of wheels that were coated with diamond dust, and about 1460 A.D. the art was introduced into Europe.

At the present time Belgium has the largest diamond-cutting industry, followed by West Germany, the Netherlands, Israel, and the United States. Smaller industries are well established in South Africa, England, and Puerto Rico. During World War II the industry was badly disorganized, and New York temporarily displaced Antwerp as the leading diamond-cutting center. In the United States there are approximately 300 diamond-cutting establishments employing about 1500 workers. The U. S. industry has the disadvantage of high labor costs.

The diamond monopoly. Of all the mineral industries, none is subject to such strict, monopolistic control as are the production and sale of diamonds. One lone firm, the De Beers Consolidated Mines, Ltd., now controls about 95% of the world's output, and it is able to restrict production, restrict sales, maintain high prices, and force the market to clamor for diamonds.

All diamonds are marketed in London through a central selling agency, the Diamond Trading Co., which is controlled by De Beers. This company sells diamonds to only a few of the very best cutters from the leading diamond-cutting centers, and they must deal through a small group of London brokers approved by the company. When a shipment of diamonds is to be sold, the brokers are notified. A broker who has an order from a particular client applies for a "sight" of the kind of stones wanted. If permission is granted to see them, the broker is given a parcel of stones containing a selection that suits the convenience of the company. The broker must buy the parcel *en bloc,* or not at all, and he will take it if he wishes to continue business with the company. However, the customer can usually sell such stones as he does not need on the diamond markets of such great centers as Antwerp and Amsterdam.

All the South African diamond fields are owned or controlled by De Beers. Through an interlocking group of these and other companies in foreign lands, De Beers has never failed to extend its control over every new diamond field of importance. It has been able to persuade both governments and private interests to accede to its judgment in matters of production, sales, and prices. Wealthy Americans, of course, pay a large part of the bill!

In a world of fickle fashion and changing values, the value of the diamond remains unimpaired. There are perhaps three reasons for the well-known fact that diamond prices are high and seldom change. First, there is the ageless emotion of love, coupled with the widespread desire for conspicuous adornment; second, the industrial demand; and, most important, the tightest monopoly that the world has ever seen.

24· Nonmetallic Mineral Building Materials

1. THE EARLY AND LATE IMPORTANCE OF NONMETALLIC MINERALS

Early use. Paleolithic man was a migratory soul who searched for food, made his clothes, and sought shelter in a hurry. This hairy hero of primitive times made effective use of wood, hides and skins, bone, and stone. Often he lived in a cave, a home of stone carved out by nature. A stone clutched in his fist was man's first hammer. Sharpened by chipping and polishing and attached to the end of a stick, the stone became an ax.

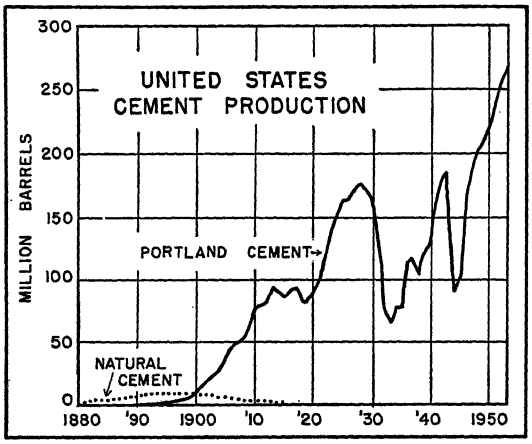
No one has a guess as to the date of the first house with a mud wall, but our guess is that the date was early.

With the patient polishing of stone tools and weapons, man emerged from the Paleolithic or Old Stone Age into the Neolithic or New Stone Age. About this time some unknown artisan fashioned pottery from clay, thereby enabling man to live at a greater distance from his source of water and to cook his food in vessels more permanent than bark. Thus stone and clay were common resources long before man made first use of copper and other metals.

With the development of sedentary agriculture, pottery was greatly improved; perhaps the plowing of fields led to the discovery of new and better clays. The arts of making bricks from clay and glass from sand were developed near the dawn of written history. The use of mortar and cement came later. From prehistoric antiquity until the present day, the nonmetallic minerals have made important contributions to the satisfaction of human wants and to the advancement of civilization.

Increasing use in modern times. The scarcity of wood and the resulting increase in the price that came with the twentieth century are forcing the people of the United States, like those of older countries, to greater use of materials from the earth's crust. After our nineteenth-century saturnalia of tree slaughter and cheap wood, we are being driven more and more to adopt the building materials used in Ancient Rome and used now in most parts of Europe, East Asia, and North Africa. Between 1900 and 1950 the per-capita consumption of lumber in the United States was cut in half, while the use of nonmetallic mineral building materials more than trebled.

Stone, bricks, sand, gravel, and cement are so commonplace that their significance in the support of society is frequently overlooked. Indeed, the value of all nonmetallic building materials produced in the United States each year exceeds the combined value of iron, copper, zinc, lead and silver. This increasing use of earth materials is a sign of the declining ratio of land to man that necessarily accom-



We turn to the earth for another fundamental of manufacture and rapid industrial growth. Permanent equipment. ***From Pit and Quarry***

panied the increase of population and the end of the frontier period.

The observant traveler in Italy will be surprised at the absence of wood in that land of stone wall and tile roofs. From the River Jordan to the Yellow Sea millions and millions of rural homes are made of mud—warm in winter and cool in summer. They can be built with a wooden shovel, and two or three poles and some brush for a roof—a mud roof.

2. CLAY AND THE BRICK AND TILE INDUSTRIES

Development of brick and tile manufacture. Clay in the form of burned or unburned brick has commonly been the first resource of peoples with whom wood was scarce, especially in arid countries. Houses of adobe or sunburned bricks have been widely used from Pharaoh's time to the present, and adobe is still a common house material through western Asia, North Africa, parts of South Europe, southwestern United States, Mexico, and some of the Andean section of South America. In these countries the mild winters and the small rainfalls permit such a building material to suffice.

In the middle temperate latitudes brick must be hardened by burning clay and shale to make them endure—and by this process they become more durable than many kinds of stone. Houses with walls of rammed earth have succeeded often enough in the eastern United States to suggest that we have here a neglected resource.

Location of the industry in the United States. While brick making in this country began as early as 1611 in Virginia and 1629 in Massachusetts, its outstanding development occurred during the latter half of the nineteenth and early years of the twentieth centuries. As the nation's population increased, there developed a rapidly growing demand for bricks in the construction industry, particularly in towns and cities where the increasing size and height of buildings called for stronger structural support and where bricks came to be used extensively for paving streets. Thousands of miles of tile were needed for sewer pipe in the cities and for the drainage of level land in rural areas. Later the construction industry came to use larger amounts of hollow tile, roofing tile, terra cotta, and other fire-clay building products.

In response to the growing demand, the brick and tile industry expanded its output at the rate of about 40% to 50% per decade, reaching its highest peak in 1909. While the output varies with seasonal and cyclical fluctuations in demand, the long-run trend in production since 1909 has been downward, largely owing to the remarkable increase in the use of cement and structural steel in the construction industry. About 6½ billion common and face bricks are manufactured in this country annually.

Bricks are heavy, bulky, low-valued, and expensive to transport. The brick plant—with its smoking kilns and clay-mixing machines that masticate the clay, shoot out the bricks by the mile, and cut them into lengths—is usually limited to a local market. Since clay suitable for making bricks is very common, brick plants can be located around the towns and cities that comprise the chief markets. It is estimated that 90% of all bricks in this coun-

try are sold within a radius of 67 miles of the plants where they were made.[1]

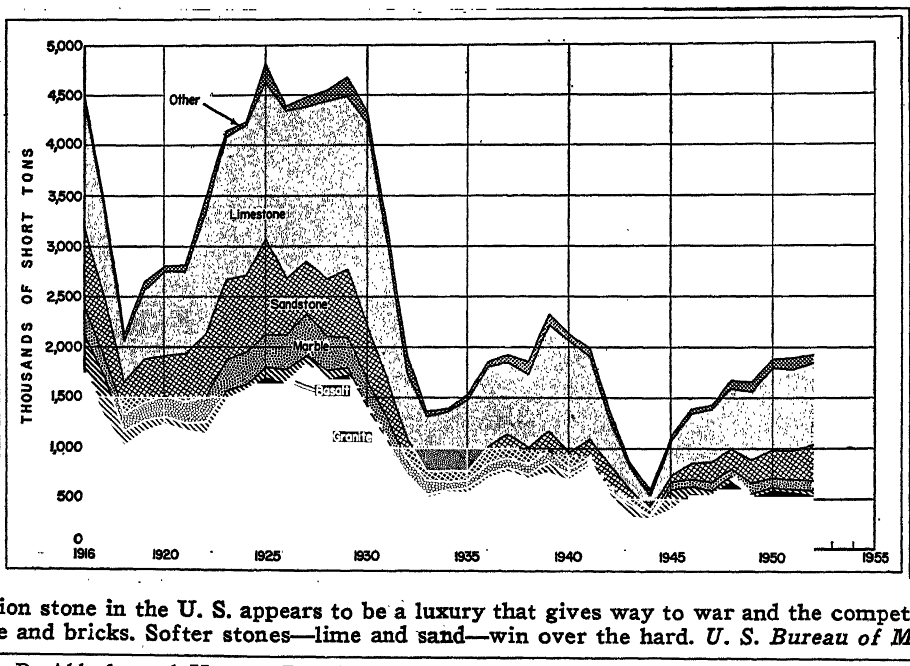
It is only occasionally that long transportation of brick is warranted because of some special quality of the bricks. Such are the widely disseminated yellow bricks made in Milwaukee, Wis., Winslow Junction, N. J., and elsewhere, and also the vitrified brick made so largely in the Ohio clay belt. The bricks of special quality mentioned are for facing fine houses. Others, called fire bricks, are very resistant to the fusing effects of heat and are used to line blast furnaces and other heated receptacles employed in metallurgy. Some of the best clay for this purpose is found beneath the Appalachian coal seams, and the most important fire-brick center is in the western Pennsylvania coal field.

Drain tile is a cheap and bulky product that is difficult to transport because it is porous and weak. Hence, it is manufactured in close proximity to the market, nearly three fourths of all drain tile in this country being produced in Iowa, Illinois, Indiana, and Ohio. This tile serves as a sort of field sewerage system to carry off surplus water from the flatlands of the North Central states, making these lands fit for tillage soon after each rain.

In a treeless and stoneless country like the Netherlands, such earth products as brick and tile are very important. Most of the houses of that country are roofed with a beautiful red clay tile, and one of the favorite interior house decorations is a glazed blue tile, called Delftware from the little city that for centuries has been well known throughout the Western World because of this tiling.

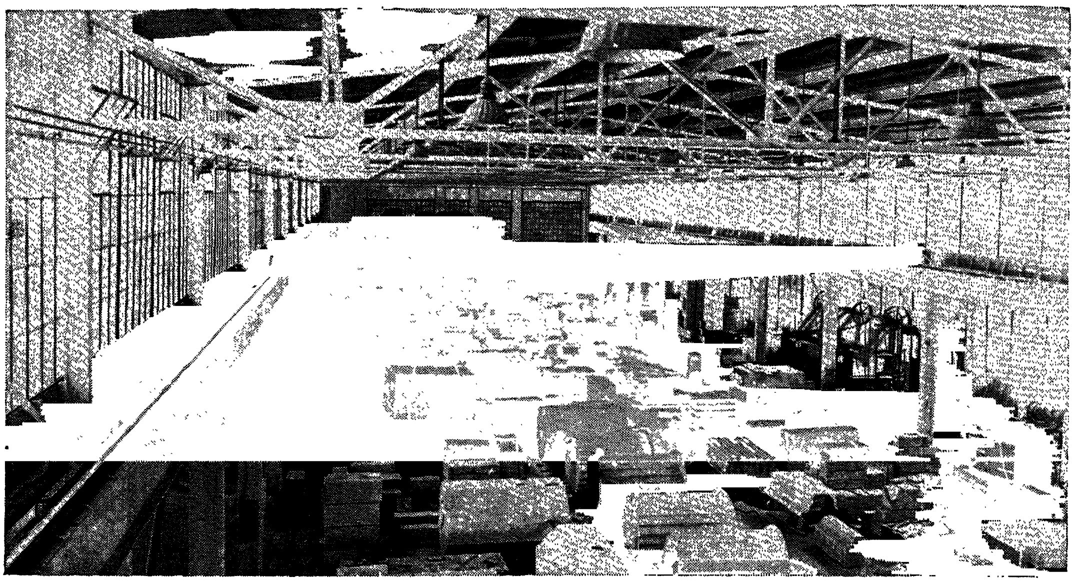
3. GRANITE, MARBLE, AND SLATE

The quarrying industry. Although brick must be manufactured and stone taken from the earth, building stone is often more expensive to use because of the large amount of labor involved in quarrying and shaping or in fitting rough stones together in the wall. The great weight of its product and the widely scattered deposits of stone make the quarrying industry, like the production of brick, tend



Dimension stone in the U. S. appears to be a luxury that gives way to war and the competition of concrete and bricks. Softer stones—lime and sand—win over the hard. *U. S. Bureau of Mines*

[1] Evan B. Alderfer and Herman E. Michl, *Economics of American Industry,* McGraw-Hill Book Co., New York, 1950, p. 209.



The traveling crane, with its own motor, picks up stone anywhere; deposits it anywhere. Standard big machine-shop equipment. Vermont marble goes to every state and Canadian province. Bed rock from the cold hills goes so far!—a tribute to business ability and work. *Vermont Marble Co.*

to be local—that is, near the consuming markets.

Exceptions are found in several places in the United States where stones of peculiar merit or unusual accessibility give rise to large quarrying industries with a distant market. For this reason New England has important quarrying industries along the seacoast where the scraping glaciers have exposed bare hills of slate, limestone, and granite. These quarries have access to the best possible transportation facilities, namely, that afforded by the seagoing vessels which can come amazingly close to the side of the quarry in many sheltered bays upon the indented coast.

Likewise in Europe cheap water transportation plays an important role in the shipment of heavy building stone to market, the excellent granites of Scotland, Norway, Sweden, and Finland being quarried near or along the coast and shipped to the plains countries of western Europe, where stone is scarce, to be used for building and paving materials. The solid Alps give abundant supplies of granite, in great demand in the home country and in the Rhine valley. Rhine boats, which bring to Switzerland coal, grain, cotton, and other raw materials for her dense population, take a return cargo of stone for the alluvial lands of Belgium, the Netherlands, and Rhenish Germany, districts nearly devoid of stone.

Granite. This is an extremely hard, weather-resistant crystalline rock that takes a fine polish and that has long been used as a building material and for monumental purposes. In 1952, 22 million tons of granite were quarried in the United States, but only 532,000 tons were sold as "dimension stone," or granite that was cut to size for use as monuments, building stone, paving blocks, and curbing. The great bulk of the output was sold as crushed or broken stone for construction work, including "riprap" for use in walls and foundations. Georgia, Massachusetts, and Vermont account for more than half the tonnage of all granite sold as dimension stone. Elberton, Ga., Quincy, Mass., and Barre, Vt., are well-known quarrying centers. The Barre district alone sells about $4 million worth of monumental granite a year, its famous "Rock of Ages" granite being found in almost every cemetery in eastern America. Such is the cost of posthumous adornment.

Marble. In southern Vermont near Rutland is one of greatest marble industries in the world. As in other extensive quarries, the

rock is cut and lifted by mechanical methods, and the product is sent surprising distances when one considers how many other good marble deposits there are in the United States. It is a tribute to Yankee energy. There are unused deposits around the Great Lakes, especially Huron, and in many parts of Appalachia. Fine marble is produced in Georgia and Tennessee, and Colorado quarries are now being worked in the sides of whole mountains of white marble. The most famous of all marble districts in the world is that at Carrara not far from Leghorn in Italy. For several centuries this district furnished practically all the world's statuary marble and, in addition, much beautiful building stone.

Slate. Slate has long been popular as a roofing material for higher-priced homes because of its rustic appearance, durability, and fireproof character. Dimension slate that has been quarried, slabbed, and split to size is also used in blackboards, billiard-table tops, grave vaults, and electrical apparatus. However, the greatest tonnage of slate is used in the form of granules for surfacing prepared roofing and in the form of slate flour for the manufacturing of roofing mastic, oilcloth, linoleum, and fillers in paints. About one third of all slate in this country is quarried in Pennsylvania between Slatington and Bangor, most of the remainder being produced in Vermont, New York, and Maine.

4. LIMESTONE, SANDSTONE, AND TRAP ROCK

Limestone. Of all the stones that are quarried in the United States, limestone is the most important, its sale of 218 million tons, worth $310 million in 1952, far surpassing that of any other stone. Deposits of limestone are found in every state, and this common stone is used for road construction, ballast along railway rights of way, building stone, concrete, as a flux in iron and steel manufacture, and as a fertilizer and soil improver on farms. This useful stone generally comprises about three fourths of the weight and two thirds of the value of all stone that is sold in this country each year. The region of chief production extends from New York and Pennsylvania westward into Missouri, with Pennsylvania, Ohio, and Michigan as the leading producers.

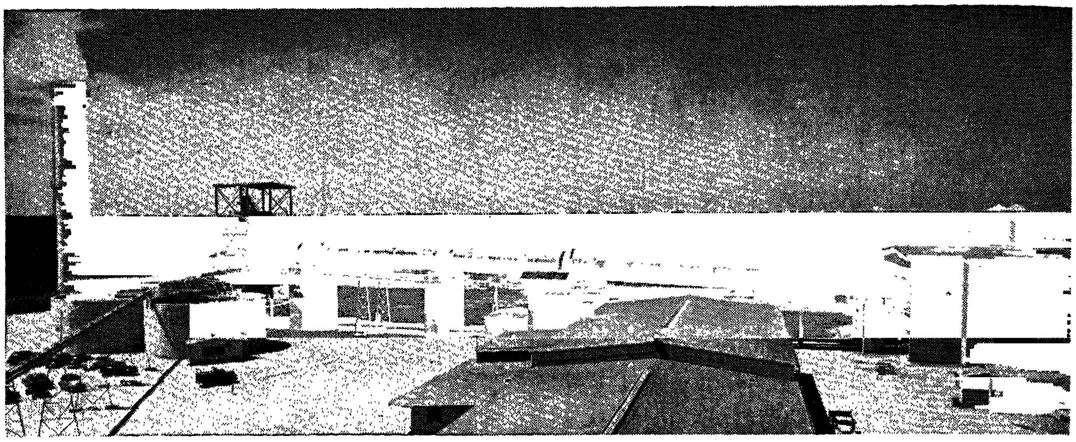
The limestone most used for building is the Indiana limestone (Bedford, oölitic) from the two towns of Bedford and Bloomington. This stone is widely used in eastern states because of its durable character and the ease with which, when first quarried, it can be sawed and worked into blocks and other desired building forms. Upon exposure to the air it hardens, as do some Ohio sandstones. Because of its high quality, Indiana limestone usually accounts for more than half the total value of all block limestone sold in this country each year.

Sandstone and trap rock. While sandstone has wide local use, it has lost favor as a building material in recent decades, for it is not so uniform in appearance or as durable as other stones. At one time the sandstones around New York City were popular for building construction, and many a crumbling old brown-stone house is still to be seen in the city. At the present time the gray sandstones of Berea, Ohio, are among the most attractive for building purposes, the stone being shipped for considerable distances. Ohio, Pennsylvania, Tennessee, and New York are now the leading producers of sandstone.

The dark-colored igneous rocks known as trap rock, chiefly basalt and diabase, are too hard to trim for building purposes, and their color is not attractive. Nearly all of the trap rock is crushed and used for surfacing roads. The quarries of New Jersey, Washington, and Oregon produce about one third of the nation's output.

5. THE CEMENT INDUSTRY

Pozzolan and natural cement. We know that cement is an enduring building material, for it was one of the materials employed by the Romans in constructing aqueducts, bridges, roads, and some great buildings that are still standing. Chunks of ancient concrete are still to be found in the wheat fields of



This long pipe, a cement kiln, filled with flame, rotates. Powdered rock travels through, falls continually through the flame, emerges the marvelously strong, marvelously cheap, marvelously useful cement. *Lehigh Portland Cement Co.*

Tunis, Spain, and other parts of the once far-flung Roman Empire. This cement of Roman times, known as *pozzuolana,* was made by mixing slaked lime with volcanic ash, and this industry still operates on the flanks of Mount Vesuvius.

During the Middle Ages cement making was virtually unknown, and not until the closing years of the seventeenth century, when many fortifications were being built, did modern man develop from various rock materials a product that closely resembled the ancient *pozzuolana.* Today pozzolan cement is made by mixing slaked lime and granulated blast furnace slag, and natural cement is made from cement rock that needs only to be burned and pulverized. Natural cement is made from cement rock and was used in this country as early as 1820 in the construction of the Erie Canal. Prior to 1900 it comprised over half of all cement manufactured in the United States. Today, however, pozzolan and natural cements are insignificant (see Fig. 422).

Portland cement. The great cement of modern times is Portland cement, which was first made in 1824 by Joseph Aspdin, a bricklayer of Leeds, England. Portland cement is now made by burning powdered limestone with clay or shale to a temperature of 2800°F., coal, petroleum, or gas being used as fuel. The resulting clinker is then ground so fine that it will pass through a screen with 40,000 openings per square inch, and a small amount of gypsum is usually added to the finished product to slow down the rate of hardening. The manufacture of Portland cement is a highly complicated process, involving some 80 different operations, the use of heavy and expensive machinery, and rigid laboratory testings in order to insure a uniform product.

When cement is mixed with sand, gravel, slag, and water, the whole mass hardens into artificial stone known as concrete. Since concrete can be poured into almost any shape, it has a unique advantage over all other building materials.

The U. S. cement industry. The advent of what is sometimes called the Cement Age in the United States was ushered in by the perfection of the rotary kiln during the later years of the nineteenth century. This machine greatly reduced labor costs and enabled production on a large scale. Among the factors that contributed to the rapid increase in cement production during the present century were the growing scarcity and higher price of wood, the adoption of specifications leading to the manufacture of uniform cement generally acceptable to consumers, the use of steel wire and rods to reinforce concrete, and the expansion of automobile production which resulted in the construction of a tremendous mileage of concrete highways. As a consequence, the manufacture of cement in the United States increased from

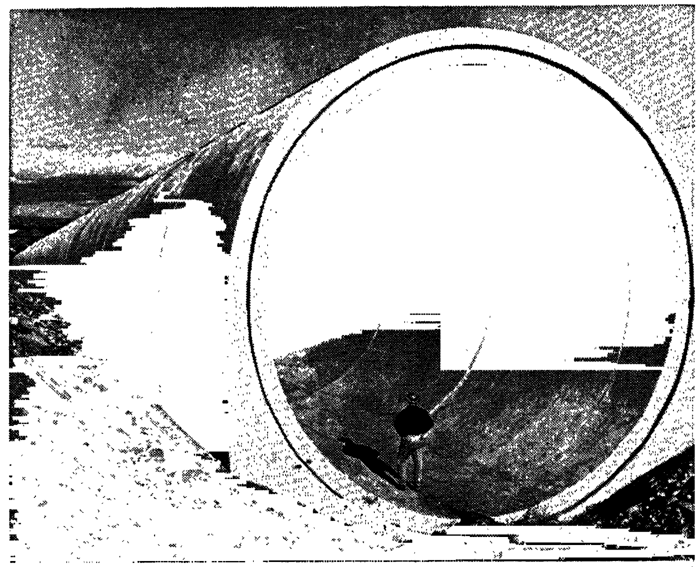
17 million barrels in 1900 to 280 million barrels in 1954, an all-time record.

Both cement and the raw materials used in making it are heavy, bulky, low-valued, and expensive to transport. A 376-pound barrel of cement, which sells for $2.55 at the plant, cannot be hauled very far without doubling its cost to the consumer. Fortunately, limestone and clay (or limestone and shale) are to be found in every state. There are few areas where at least one fuel—coal, oil, or gas—cannot be obtained for industrial use. Therefore, cement plants are located close to the market, the distribution of plants roughly coinciding with the distribution of population.

Portland cement is manufactured in 37 states, Pennsylvania, Texas, California, New York, and Michigan being the leading producers, with a combined output amounting to nearly half of the nation's production (see Fig. 428).

In contrast with the wide distribution of cement manufacture that prevails today, production 50 to 60 years ago was heavily concentrated in the Lehigh valley of eastern Pennsylvania. In 1900 this district produced about 70% of the nation's cement.[2] The Lehigh Valley has the advantages of high-grade local limestone and shale, nearby anthracite coal, a good labor supply, and is equidistant from New York and Philadelphia. Although its output has continued to increase, its relative importance has declined as production has increased in other parts of the country. The Lehigh Valley now produces about 15% of the nation's cement.

Foreign production. Because of the great importance of the natural cement industry in England and the high reputation of its product, it was not until the 1850's that Portland cement proved its superiority over natural cement, but thereafter the industry expanded rapidly in England and spread into Belgium and Germany. European manufacturers turned out a high quality of Portland cement, shipping large quantities overseas. United States imports of European cement increased rapidly between 1878 and 1893, and it was not until 1896 that our domestic production exceeded imports.



Permanent equipment for the future. Concrete siphon, 25-foot diameter, carries 2,500,000 gallons of irrigation water a minute down and up and across valley 2 miles wide. Columbia River water. *U. S. Bureau of Reclamation*

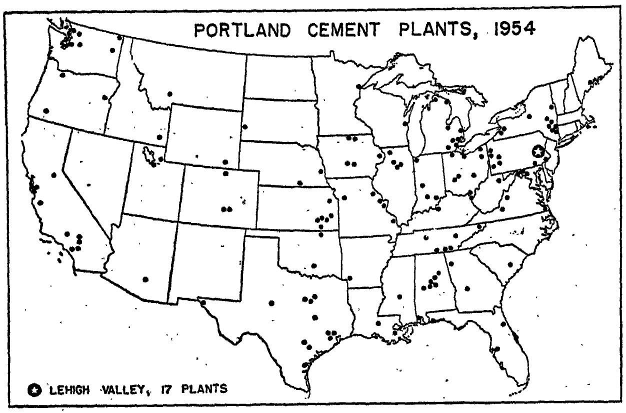
West Germany, the Soviet Union, Great Britain, France, Italy, and Belgium lead Europe in cement production. In most years Europe and the United States produce about 75% of the world's cement.

Cement is now manufactured by more than 50 nations and colonial territories. Japan is the leading producer outside of Europe and this country. The nations of northwestern Europe continue to be the leading exporters of cement, but many countries have achieved self-sufficiency, and since World War I the world trade in cement has declined.

6. POTTERY AND PORCELAIN

Early production. The making of pottery from clay, first developed by Neolithic man, was a well-established art in the Old World civilizations of Babylonia, Egypt, China, and

[2] *Ibid.*, p. 186.



Is any other manufacturing industry so evenly distributed with regard to population? ***Adapted from Pit and Quarry publications map***

India, and in the New World civilizations of Maya, Aztec, and Inca. Porcelain, a semitranslucent form of chinaware, has been made in China for well over 1000 years. Hence, our name for it. They taught us. In many parts of the world, as in the Far East, many sections of Latin America, and among the Indians of our Southwest, the manufacture of pottery remains a handicraft trade, and even in the modern factory a large amount of skilled labor is required.

Modern manufacture. The pottery industry of today includes a wide range of products, such as bathroom and toilet fixtures, hotel and household chinaware, red earthenware, porcelain electrical supplies, and garden ornamental pottery. In the United States chinaware and sanitary ware comprise about half the total value of the output of the pottery industry. While our ultramodern bathroom facilities are perhaps not the quintessence of American civilization, they are indeed the envy of the rest of the world.

Although common clays will often make satisfactory pottery, the finer ceramic wares usually require pure clay, such as kaolin, or china clay, which can be heated to 3000°F. without melting. Other raw materials include quartz (to give rigidity to the product), feldspar (which acts as a flux to bind the materials as they fuse), and various glazing materials (to impart a glossy finish to the outer surface of pottery). In early times unusual skill was required to mix successive batches of raw materials that would produce exactly the same quality, but in the modern establishment the materials are apportioned, finely ground, and mixed mechanically with scientific precision and then put through a filter press and allowed to season.

After the "green" clay is given the desired shape by pressing, jiggering, or casting, it is burned or fired. Except for the most common ware requiring no gloss, there are two firings, one known as "biscuit" firing to fix the form of the ware and a second known as "glost" firing to vitrify the product after the glaze solution has been applied. This may be done in a stationary kiln, a conical structure in which the clay forms are stacked by hand. A more recent development is the tunnel kiln, about 300 to 500 feet long, through which cars convey the clay forms, the midsection of the kiln being heated to a temperature high enough to fuse the clay. The tunnel kiln permits continuous operation and, together with the use of belt conveyors and other automatic devices for transferring the green wares from one process to another, has proved a great boon to large-scale production. Note the close resemblance to an assembly line.

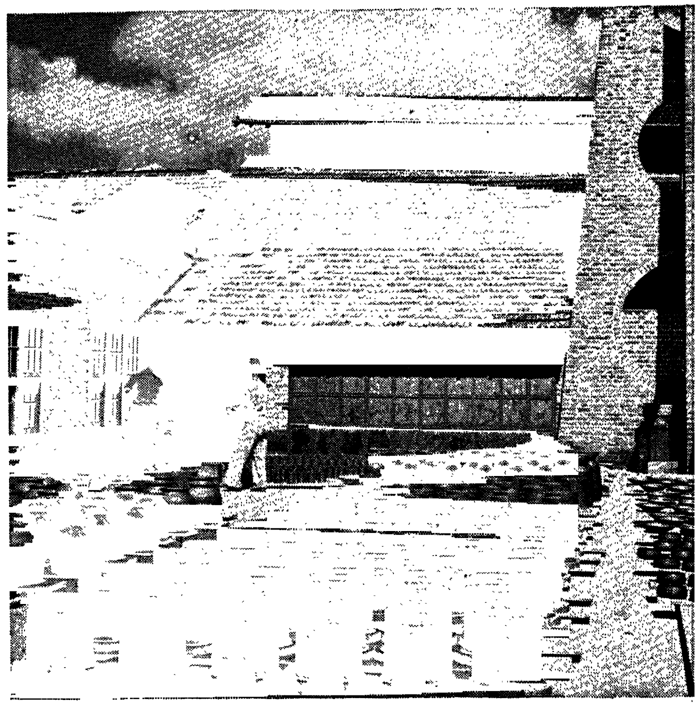
Pottery and porcelain in Europe. Special porcelain centers have been important since the origin of world commerce. Early in the eighteenth century a German rediscovered the very old Chinese art of porcelain making. A royal factory was established at Meissen, Saxony, and another at Berlin. Dresden china, however, is probably the most internationally famous of all German porcelain ware. For years prior to World War I, Germany was the world's leading manufacturer of porcelain. Austria and Czechoslovakia also have important porcelain manufactories, the products of which are exported in considerable quantity.

For the last century and a half, France has been Germany's chief rival in the production of fine porcelain, the factory at Sèvres having

long been the rival of the German factories at Meissen and Dresden. The town of Limoges has given its name to a fine porcelain ware, much exported to the United States.

Since the fifteenth century, Majolica ware has been exported from Majorca, one of the Balearic Islands, where the industry originated through the influence of the Saracens. Italy has long been known for its export of faïence, a soft-finished, highly decorative pottery produced in Faenza.

In Staffordshire, England, a group of towns known as "the Potteries," in the vicinity of Stoke-on-Trent, has been the great center of china and earthenware manufacture since the sixteenth century. One of the towns is Burslem, birthplace of Josiah Wedgwood, originator of the famous chinaware that bears his name. This district is well supplied with coal and at one time used local clay, but now most of the clay is brought in from Cornwall and Dorset. England is not only the leading exporter of chinaware but ships large quantities of high-grade china clay (kaolin), chiefly from the Cornish port of Fowey, to many foreign lands.



Clay, mixed, dried, and burned, has made useful vessels for thousands of years. A simple industry. Compare Fig. 431, another earth material industry. This is São Paulo, Brazil.

Pottery and porcelain in the United States. While the production of pottery in this country began in early colonial times, it was not until after 1850 that the manufacture of better grades of white ware got under way. For years our pottery industry was concentrated at Trenton, N. J. Although some high-grade chinaware is still produced in Trenton, the city is now famous chiefly for its output of sanitary ware.

Ohio is now the leading pottery state, with East Liverpool as the major producing center. At Zanesville and other Ohio and West Virginia towns are scores of potteries utilizing Appalachian coal and both domestic and foreign clays. About 70% of domestic kaolin is obtained from Georgia, 20% from South Carolina, and much of the remainder from Pennsylvania.

Although American potteries have turned out some excellent china ware, such as Lenox that has taken prizes at international expositions, our more wealthy citizens prefer the imported product. In this country the emphasis has been on quantity rather than quality, medium and low-priced chinaware reaching the average family over the counters of department stores, 5-and-10-cent stores, and through other economical channels of distribution. In the quantity and quality of their sanitary ware, however, U. S. potteries have no peer.

China and Japan. China, so long famed for its porcelain, taught the trade to the Japanese centuries ago, and the pupils now rival their teachers in the excellence of their porcelain. This old Japanese industry long depended on charcoal from the wooded hills and hammers driven by water wheels to grind the clay and stone. The destruction of forests in the pottery districts has caused the use of coal to be introduced; but fuel is economized by having ovens placed one above the other upon the sides of steep hills, so that the heat passes from one

oven to the next, and is thus made to perform its greatest service. The Japanese porcelain makers, like the other Japanese artisans, were, until a recent date, individual artists, but the quality of their product is declining, because of wholesale manufacturing and the desire to make cheaper goods for the foreign markets.

7. THE MANUFACTURE OF GLASS

The nature and location of glass making. Glass is essentially fused sand, very much as pottery is fused clay. When sand is mixed with soda ash, lime, and broken glass, and other ingredients[3] and is heated to a temperature of 2500° to 3000°F., it melts to a sticky, noncrystalline mass that cools slowly and can be easily worked into finished products of various shapes. Glass sand must be high in silica and low in iron oxide and alumina if clear glass is to be made, and if the sand particles are small, uniform, and angular, much better fusion results.

Raw materials do not play a dominant role in the location of glass manufacturing. Their cost is only 10% to 15% of the total cost. Glass sand is comparatively abundant, and scrap or broken glass may comprise as much as 50% of the material. Proximity to markets, because of the high freight rates on glass, and the availability of fuel, particularly natural and artificial gas, are now the major factors determining the location of the industry.

With modern methods of manufacture, glass can be made that is transparent, translucent, or opaque, brittle or shatterproof, pliable or tough as iron. Fiberglass is now competing with natural fibers in the manufacture of textiles and clothing, glass bricks are being used increasingly, and already glass is replacing metals for various uses. At the present time, however, the principal markets for glass are in the manufacture of containers for bottling beverages, foods, medicines, and other products, window glass for buildings, plate glass for automobiles, and table and kitchen ware.

The glass industry in the United States. The United States leads the world in the manufacture of glassware. Like iron, the industry began with a wood-burning epoch, which caused it to be centered in New England and the eastern states. In 1776 a glass company established itself at Glassboro on the sands of south central New Jersey, where a tract of 35,000 acres of woodland growing on sand was secured to produce the fuel. With the depletion of forests, New Jersey glassmakers turned from charcoal to the use of producer gas obtained from coal, and more recently they have shifted to fuel oil, which is delivered cheaply by tanker to Delaware River points. For some time Philadelphia and the New Jersey towns of Bridgeton, Salem, Millville, and Glassboro were among the leading glass-manufacturing centers in the country, but years ago most of the glass industry migrated westward to be near the Appalachian coal and gas fields.

Natural gas and the artificial gas obtained from coal make ideal fuels, for they are easily controlled and produce a high and uniform temperature. The importance of fuel and market factors in determining the location of the industry is revealed by the heavy concentration of glass-manufacturing plants in western Pennsylvania, northern West Virginia, eastern Ohio, western New York, and central Indiana. Toledo, Ohio, in recent years has come to rival Pittsburgh, Pa., as the leading center. Glass manufacturing serving local markets has also developed around Chicago, in eastern Oklahoma, and in southern California.

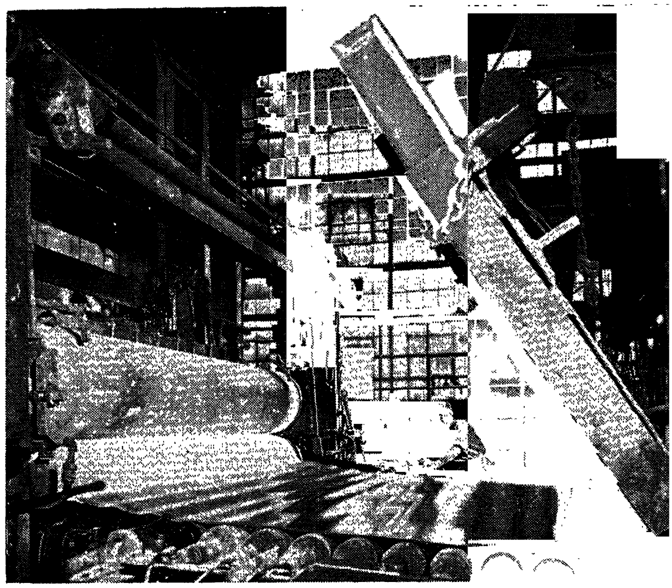
The United States imports some high-quality European glass products. Since World War I, however, great progress has been made

[3] Lime in the form of calcium oxide and carbonate gives hardness and permanency and facilitates melting and refining. Soda ash, or sodium carbonate, which costs five or six times as much as sand, serves as a flux to facilitate the mixing and melting of other ingredients. Scrap or broken glass not only helps to reduce raw-material costs but also shortens the melting time, reducing fuel costs. Salt cake, or sodium sulfate, helps to lower the melting point and viscosity of glass, but its use has been declining with the increased adoption of automatic temperature control. Other raw materials include potassium carbonate and nitrate, boric acid, borax, and small amounts of coal, lead, barium, arsenic, and antimony.

in this country in the manufacture of glass for optical and scientific use, with important centers at Corning, N. Y., Rochester, N. Y., and Huntington, W. Va. The old New Jersey glass industry has come to specialize in laboratory glass and other quality products.

Glass-making processes. At the present time glass is melted in regenerative furnaces, similar to those used in steel making, with capacities ranging up to 1500 tons. Various mechanical devices have been perfected by which the molasseslike molten glass either flows out, is poured out, or is sucked out of the furnace, after which it is ready for shaping —which may be accomplished by rolling, drawing, pressing, casting, or by blowing the viscous material into shape with the use of compressed air. After shaping, it is necessary gradually to cool or anneal the glass, this being carefully done in long tempering ovens known as "lehrs."

For a long time practically the only means of shaping glass was to dip a long tube into the clear pool of liquid glass and blow through the tube, so that, by whirling and blowing, the expanding bubble of molten glass became, upon cooling, the desired vessel—a craft of almost unbelievable skill. For window glass it was blown into cylinders, which were cut open and allowed to fall upon a table to cool. Glass blowing is difficult work, requiring very great skill and commanding high pay. In the manufacture of bottles one of the glass blower's most difficult problems was to dip out of the tank the exact amount of glass needed, an obstacle that was not solved until 1903 when Michael Owens, an Ohio glass blower, invented a rotating wheel with arms equipped with plungers using the suction of compressed air to pull up a specific amount of molten glass. The Owens machine, coupled with the use of conveyor belts and other mechanical devices, can now produce 75,000 bottles a day. The manufacture of containers is now the most important branch of American glass making.



Molten glass, 100 inches wide, temperature 1700°F., shaped by big rolls, becomes hard enough to hold its shape at 1500°F. and is polished on both sides as it passes through a machine 880 feet long, before being cut into desired lengths. Runs without stopping 700 to 800 days. *Pittsburgh Plate Glass Co.*

In the manufacture of ordinary window glass, mechanization has gone so far that the entire output in this country is produced by an automatic, continuous process. One result of automatic production has been a reduction in the number of plants and companies. Four companies produce virtually all the window glass in the United States, namely, the Pittsburgh Plate Glass Co., the Libbey-Owens-Ford Glass Co., the Fourco Glass Co., and the American Window Glass Co. Two companies —Pittsburgh Plate Glass and Libbey-Owens-Ford—account for more than 90% of the nation's output of plate glass.

Plate glass. Plate glass differs from window glass in that it is ground and highly polished. In 1922–23 the Ford Motor Co. and the Pittsburgh Plate Glass Co. developed a new method consisting of continuous drawing, rolling, grinding, and polishing which greatly speeded up production.[4] As the automobile

[4] The late Henry Ford, nettled by the high cost and large breakage of the plate glass part of an automobile, thought it ought to be made more cheaply. He had an idea. He called into consultation all the

manufacturers in the 1920's turned more and more to the production of closed cars and as in the following decade they equipped cars with laminated or shatterproof glass, which requires two sheets of glass or double the area of glass per car, the demand for plate glass was greatly stimulated. In recent years about three fourths of all plate glass in this country has been used by the automobile industry.

Glass manufacture in Europe. In the coal-rich countries of northwestern Europe are to be found favorable conditions for the manufacture of glass: a large supply of producer gas, cheap skilled labor, and great markets. In Great Britain the chief glass-making centers are in the coal-mining areas near Newcastle, Birmingham, and Bristol. Metropolitan London is a large market for glass and an important producer, its glass works using gas manufactured from coal that has been carried from Newcastle by coastwise vessels.

For many years Belgium has had an important glass industry, which is located along the edge of the coal fields of Liége and Charleroi close to sand quarries and soda factories. This district is the largest producer of window glass in Europe and supplies one of Belgium's leading exports.

In France the manufacture of window and plate glass is concentrated near the coal fields along the Belgian frontier. Paris is the center of optical glass manufacture, and Baccarat has long been renowned for delicate crystal ware. The Saar Basin also has an important glass industry.

All kinds of glass are made in West Germany, which ranks second to the United States in production. The leading glass-making district is located in the coal-rich Rhine-Ruhr region, with Essen, Gelsenkirchen, Düsseldorf, and Cologne as major centers.

For many years the city of Jena in central Germany was the home of the famous Zeiss works, known throughout the civilized world for the high quality of its telescope, microscope, and camera lenses. In June 1945 Jena was occupied by the Russians, who promptly removed $100 million worth of goods and machinery and deported 336 skilled workers to the Soviet Union. Three days before the Russians arrived, 130 top scientists and executives escaped to the American zone of occupation. These men established a new factory, known as Zeiss Opton, about 10 miles from the little village of Heidenheim. New and larger plants were built later at Oberkochen and Stuttgart. Once more Zeiss quality products are being sold in many foreign lands.[5]

Czechoslovakia now lies behind the Iron Curtain and exports little to the free world. In prewar years the colored glass and crystal made in Bohemia were world-famous.

In the Soviet Union the Five-Year plans have resulted in the development of glass making along with other heavy industries. Glass is manufactured on a large scale in the Ukrainian, Moscow-Gorki, Leningrad, and Ural industrial areas. In Soviet Asia it is produced in Krasnoyarsk, Tomsk, Irkutsk, and Ulan-Ude. The entire glass output of the Soviet Union is destined for home consumption.

---

plate-glass experts. They told him his idea was crazy. He paid them their fees and dismissed them. He started a little plant and worked in it a large part of the time for two years, and as a result he cut the cost 80%. He made glass by a system that begins by running a stream of molten glass across a moving platform at the rate of 53 inches a minute. Careful study showed this to be the speed to let the glass cool off at such a rate that it can be pressed, polished, cut into lengths without ever stopping its movement. As a result, this continuous stream of plate glass flows night and day, and the machinery stops only when it is to be replaced after being worn out. The Ford Motor Co. has the facilities to produce 45 million square feet of plate glass annually, but it has not produced any glass since 1931.

[5] See Max Eastman, "A New Life for Zeiss," *The Reader's Digest*, October 1951, pp. 47–50, and "Camera Comeback," *Time*, January 18, 1954, p. 84. The Zeiss works were the result of teamwork—Abbe, professor of mathematics in the University of Jena, and Carl Zeiss, local optician. The senior author knew Abbe.

25· The Metal-fabricating Industries

1. THE MACHINE-TOOL INDUSTRY

The nature and importance of machine tools. The manufacture of iron and steel, copper, aluminum, and other metals does not end with the production of ingots, bars, billets, blooms, plates, slabs, sheets, tubes, rods, and wire. Before these primary products can be of use, they must be properly shaped. This is the job of the machine tool, a power-driven machine that is used to cut or shape metal.[1] Machine tools make machines (almost).

A miracle machine. A carpenter has saw, plane, augur, and other tools. With them he bores, cuts, and shapes wood with the strength of his own muscles. He can cut metal by the same process, but the amount that he would do— ? —practically nothing a day with some of the hard metals now in use.

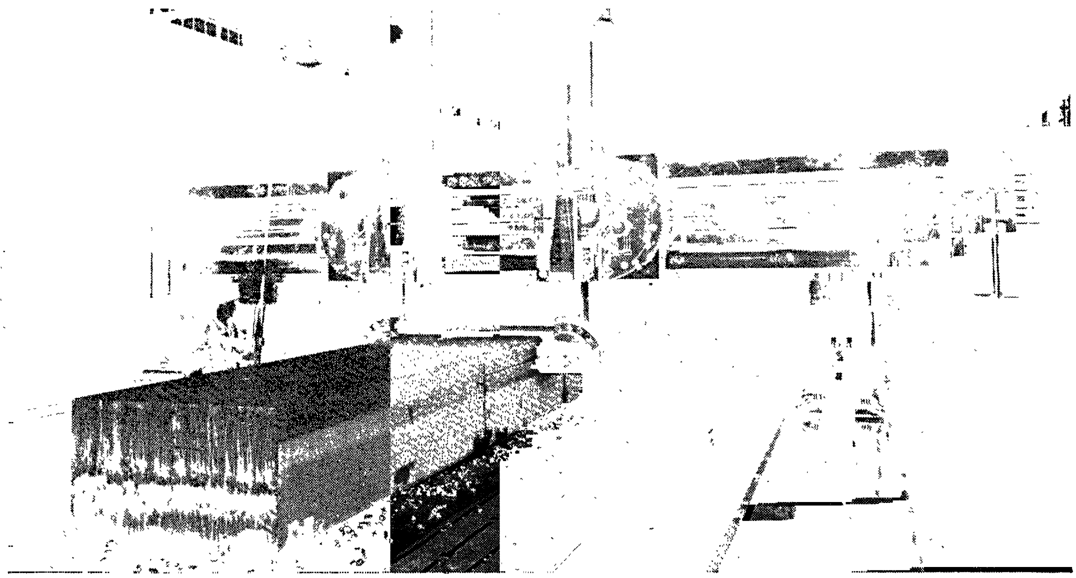
In today's machine shop, the machinist who operates a planer, one of the machine tools, takes a piece of hard steel casting as wide as your outstretched arms and twice as long or even more. He clamps it fast in a mighty frame, pushes a button, and his planing machine, driven by a 40-h.p. motor, drags a chisel of still harder steel across the casting. As the chisel goes forward it cuts chips of hard steel from the surface of the casting. When the chisel reaches the end of the casting it stops, runs quickly back to the starting point, moves over a bit, and cuts another strip of shavings in the process of smoothing the casting.

The machinist has set the machine and started it. That is all, except that he watch to see that a stream of oil or water flows constantly on the chisel to keep it cool. In 30 minutes that machine may do as much planing as the man could do in 30 days with hand tools.

Now you see why the machine tool is one of the parents of the Machine Age. Another of its ancestors is high-speed steel—cutting tools of almost unbelievable hardness, made of alloys—new combinations of metal—first compounded within this century.

Two major groups. There are two major groups of machine tools: (1) special-purpose machines designed to make a specific product, usually on a rapid-production basis, such as the machine that produces 150 automobile rear-axle housings per hour with one operator, and (2) general-purpose machines that are

[1] The National Machine Tool Builders' Association defines a machine tool as "a power-driven complete metalworking machine not portable by hand, having one or more tool or work-holding devices and used for progressively removing metal in the form of chips." There are many metal-working machines that do not conform to this definition, for example, hydraulic and mechanical presses, bending machines, and forging machines that do not remove metal progressively in the form of chips or shavings.



A machine tool—planer—cutting chips from a block of steel, part of Cyclotion magnet. Note size of man, and length of the cross member that carries the chisel. ***Bethlehem Steel Co.***

adaptable to shaping diverse products, such as milling and planing machines.

Machine tools take months to design, months more to make, and until recently they have not been mass-produced. Skill and precision are the essence of machine-tool making and modern science plays a major role.

Machine tools vary in size from small machines, such as workshop lathes that sell for a few hundred dollars apiece, to 250-ton monsters that automatically cut and shape a 32-foot section of an airplane wing and cost as much as $500,000. These ingenious devices are the master tools of industry. Without them, the large-scale production of modern machinery, including machines that make machines, would be utterly impossible.

Five basic functions. While machine tools vary greatly in form, size, and use, in general it may be said that they perform five basic functions: milling, planing, turning, boring, and grinding. Each of these operations has long been accomplished by hand or by very simple mechanical aids.[2] For each of the five basic metal-working operations exceedingly efficient machines have been devised.

The modern power-driven milling machine consists of a rotary cutter with multiple cutting edges and operates much like a circular saw. A modification of the milling machine is the hobbing machine for cutting gear teeth. Planing machines will, when once set and started, work for hours smoothing one side of a piece of metal as big as the floor of one or two small rooms. Turning consists of shaping a rotating piece of metal into cylindrical or other curved surfaces with an ordinary lathe, the oldest of all machine tools.[3] The modern turret lathe is so designed that the operator can bring a succession of different cutting edges to the work over and over again, one at a time, to perform the various operations required and thereby turn out almost any shape that a pattern may prescribe. A turret lathe can usually turn, bore, and shape at the same time. Boring or drilling is done by single- or multiple-spindle machines that cut, enlarge, or finish a round hole with a rotating cutting

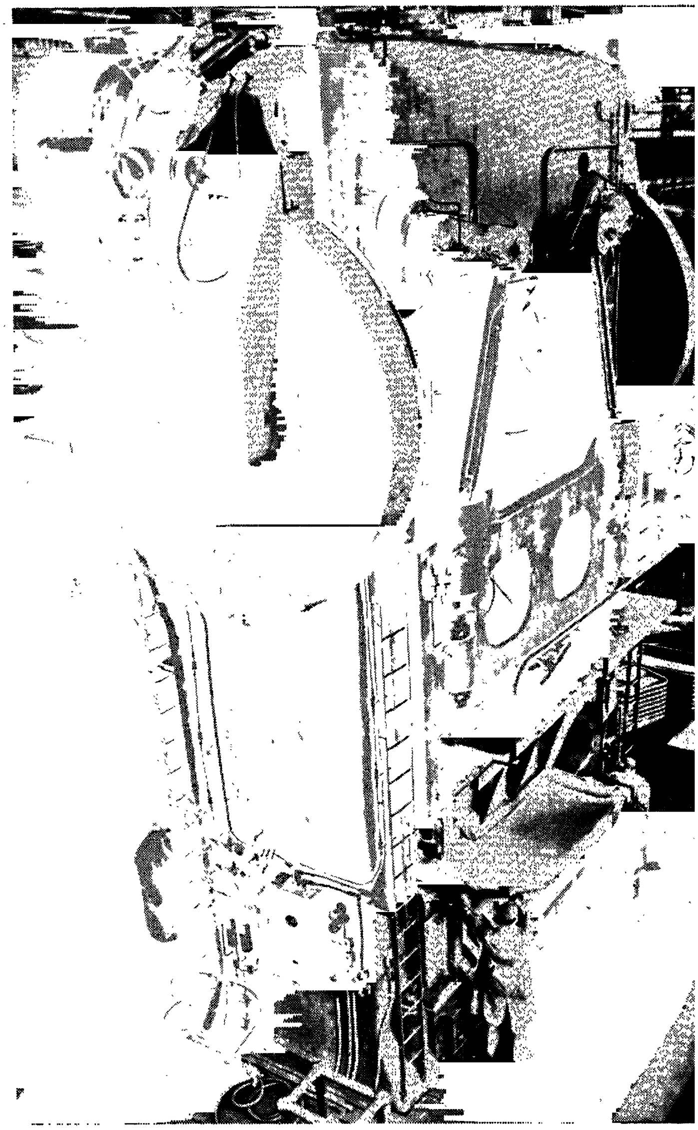
[2] In woodworking, the carpenter uses the chisel, plane, saw and lathe, brace and bit, sandpaper and stone to perform these functions, all of which have been mechanized in large woodworking establishments. In metals they reach gigantic size.

[3] It was the perfection of the engine lathe that made possible the large-scale production of steam engines.

tool, and some machines can drill more than 100 holes at one time. Grinding consists of shaping a piece of metal by bringing it into contact with a rotating abrasive wheel, and it includes such finishing processes as polishing, buffing, and lapping. While a lathe can turn out work that is true to within 1/64 of an inch, the precision grinder will grind either round or straight within limits of 2/10,000 of an inch. Sometimes two or more basic operations are performed at the same time, as in the case of turret lathes, combination milling and planing machines, and combination milling and boring machines.

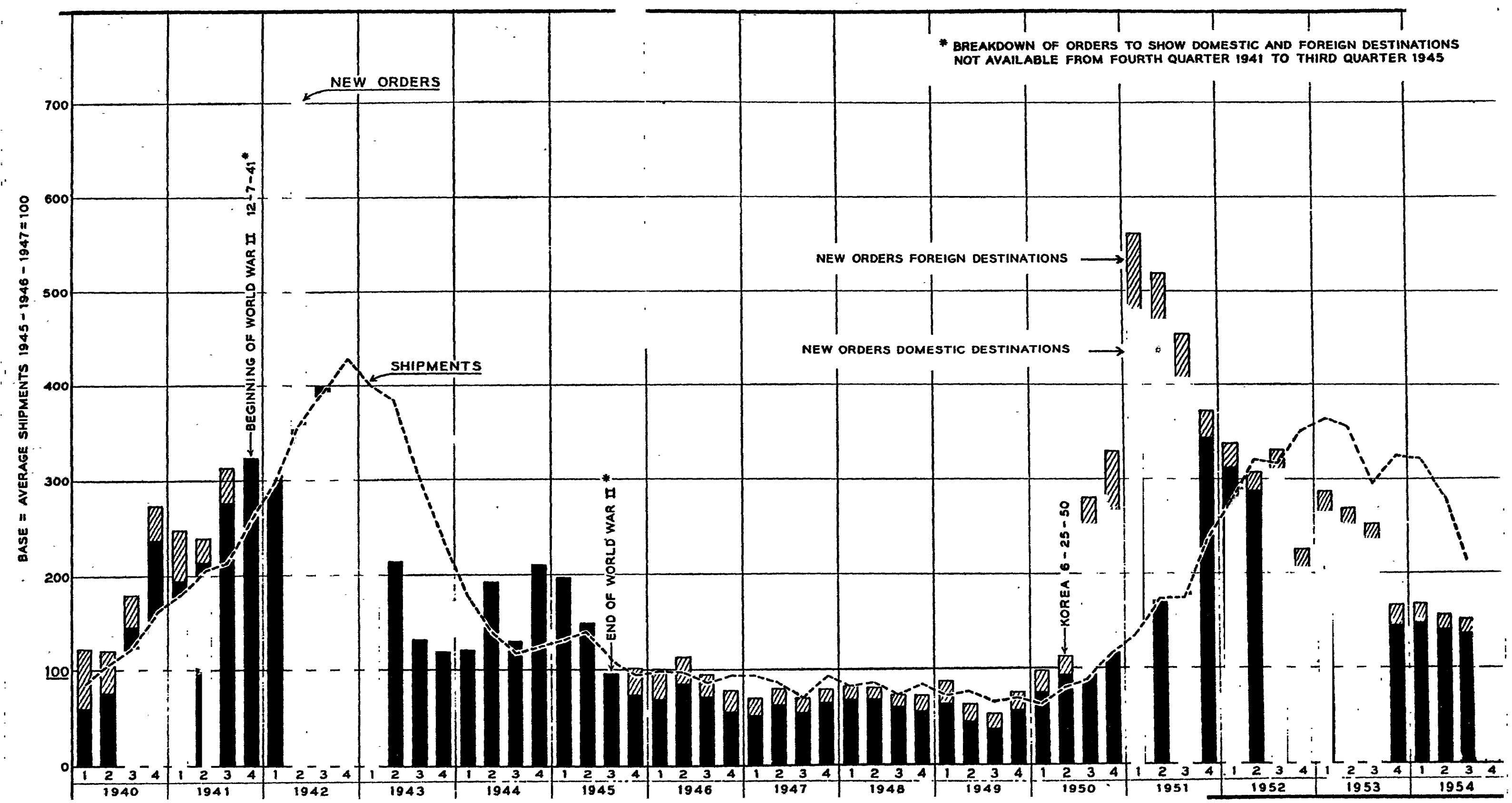
Most of these machine tools have been improved to the point where they become automatic. This condition is attained when a machine will take pieces of material and turn out a uniform product. Thus, a roll of wire is fed into one end of a machine, and finished wire nails come out at the other. A roll of brass or steel wire is converted into screws, and each of the necessary processes is done by a machine that takes or makes the blanks by the bushel and works them up into a finished article of remarkable cheapness. Again, a rod will be cut into series of perfect bolts, nuts, or screws of exact dimensions and each just like all the rest. That likeness is the great economic secret of this mechanical age.

The U. S. machine-tool industry. As New England was the birthplace of the Industrial Revolution in America, so it was the cradle of our machine-tool industry. The first milling machine in this country was devised in 1818 by Eli Whitney, famed inventor of the cotton gin, for making the first interchangeable parts used in guns. Manufacturers of firearms were the first to produce smaller precision machinery, while the builders of textile machines and engines began the production of heavier types of machine tools. With its large pool of skilled labor, New England remains a major producer of machine tools. Among the leading centers of production are Worcester and Fall River, Mass., Bridgeport, New Britain, and Hartford, Conn., and Providence, R. I.



Magnitude, the work of fairy-tale giants. 700-ton mechanical press stamping an auto top. Press work increasing in importance: used on steel sheets ½-inch thick. The press makes pieces that erstwhile were machined. ***National Machine Tool Builders Association***

Approximately three fourths of all machine tools are now made in seven states—Ohio, Michigan, Connecticut, Illinois, Rhode Island, New York, and Massachusetts. Cincinnati, Ohio, is by far the leading center of production, with nearly 20% of the nation's capacity. In recent years there has been a tendency to



Report on machine tools, U. S. orders and shipments quarterly periods. The mountainous peaks of this graph back up the statement "War is machinery," and fear of war makes machinery. *National Machine Tool Builders' Association*

locate machine-tool plants in the Detroit area, the automobile industry being the largest purchaser of machine tools. Other midwestern centers of production include Cleveland, Sydney, and Dayton, Ohio, Milwaukee and Madison, Wis., Chicago, Ill., and Indianapolis, Ind.

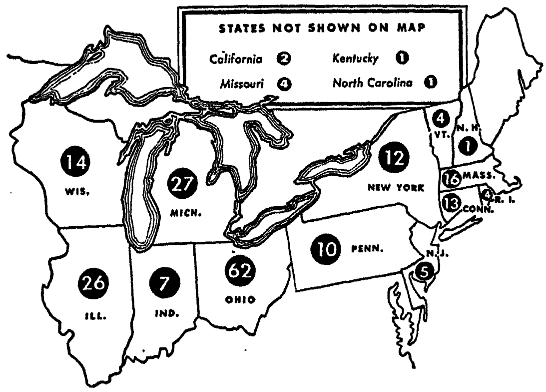
The United States machine-tool industry is of moderate size. The industry consists of some 300 firms, no one of which accounts for as much as 10% of the total output. No single firm makes a full line of tools, and even the largest companies usually limit themselves to a few types. About two thirds of the establishments employ less than 100 workers, and only four companies employ more than 2500. Labor is the largest single cost factor, wages and salaries accounting for nearly half of the value of products shipped.[4]

The United States continues to lead the world in the manufacture and export of machine tools. In postwar years between 20% and 30% of our output has been shipped abroad, chiefly to Great Britain, Canada, France, Argentina, Brazil, and Mexico. Imports amount to only 1% of domestic production.

Machine-tool manufacture in Europe. Western Europe is well endowed with cheap skilled labor, and its machine tools have long been famous for the unusual precision with which they are made. In many instances labor represents 70% to 80% of the total cost of European tools.

The machine-tool industry of West Germany is now the world's second largest producer and a major exporter of machine tools. Production is concentrated largely in the Rhine-Ruhr region, with Düsseldorf, Frankfurt, and Cologne as major centers. Dresden, Chemnitz, and Leipzig in East Germany were important prewar centers of production, but little is known of their present activity.

Great Britain, the first nation to make machine tools, ranks third in production. The British normally have a large surplus for export, chiefly to British dominions, France,



Location by states, members National Machine Tool Builders' Association. The industry started in New England, moving toward center. *National Machine Tool Builders' Association*

the Netherlands, Luxembourg, and the Soviet Union. In 1951–53 Great Britain led all nations in the purchase of American machine tools.

Switzerland, Sweden, and Belgium have limited home markets and have long been exporters of high-grade machine tools. In contrast, France, Italy, and the Soviet Union do not produce enough machine tools to meet their needs and remain dependent upon imports.

2. INDUSTRIAL MACHINERY

Textile machinery. Great Britain was the first to manufacture cotton and woolen textiles with power-driven machines and the first to develop a great textile-machinery industry. For many years the manufacture of cotton textile machines has been concentrated in Manchester, Bolton, and other towns in Lancashire, close to the mills of Britain's great cotton textile-manufacturing district. Likewise, the production of woolen and worsted textile machines is centered chiefly in Bradford, Leeds, and other Yorkshire towns. Leicester and Nottingham produce machines for making hosiery, Macclesfield makes silk machines, Dundee specializes in jute machines, while the Irish city of Belfast predominates in

[4] For details of the industry, see Edward L. Allen, *Economics of American Manufacturing,* Henry Holt & Co., New York, 1952, pp. 261–284.

the manufacture of machines for making excellent linen. Linen industry is important there.

At one time or another British textile machinery was exported to almost every country in the world. In the 1930's British pride was hurt when mill owners purchased a number of ring spindles and Toyoda looms from Japan, also when the British public used £400,000 worth of Japanese cotton goods in a single year. (The supreme indignity occurred in the early 1950's when Americans carried coal to Newcastle.)

In the United States well over half of all textile machinery is manufactured in New England, which only since 1924 has been surpassed by the South in cotton-textile production and which still leads in woolen and worsted manufacturing.

Some companies make only spindles; others specialize in looms; still others make machines for dyeing, washing, and carding; while some are engaged in the production of humidifiers and air-conditioning apparatus. Textile machinery made in Worcester, Lowell, Hyde Park, Whitinsville, Mass., and other New England towns has long been used locally and throughout the nation. Philadelphia, a great textile center, is also an important producer of textile machinery.

The manufacture of textile machinery is important not only in Great Britain and the United States, but it is well established in Japan, Germany, Belgium, France, Italy, Switzerland, and the Soviet Union. Production has begun in India and a number of other countries.

Other machinery for manufacturing. The production of most machinery for manufacturing, like textile machinery, tends to occur near the place where used. This industry is a kind of parasite, a hanger-on or a purveyor to other manufacturing industries. Aside from the saving of freight charges, there is a great convenience resulting from the ease in making repairs and replacements when the machine-producing factory is near the machine-using factory. Furthermore, improvements in machines are most likely to be conceived by people who use and repair them and watch them while they work.

It is not surprising, therefore, that most of the nation's shoe machinery is produced in the Boston and St. Louis areas, in the midst of great shoe-manufacturing districts. Likewise Ohio, with its huge rubber-manufacturing industry at Akron, is the foremost producer of rubber machinery.

Engines and motors. Engines or electric motors are used in almost all kinds of factories, and also in nearly all mines and on many farms. Their market is not quite so restricted as that for machine tools, but their manufacture is located by the same factors and is distributed in the United States from Lake Michigan to the Atlantic and southward to southern Pennsylvania. Some of the heaviest engines in the United States are made at Milwaukee, Wis. Further east, Pittsburgh with its huge iron and steel plants, requiring so much heavy machinery, is an important center for the manufacture of heavy engines and electrical machinery. The highly industrialized areas around Philadelphia and New York and in southern New England are major producers of engines. Schenectady, N. Y., and Pittsburgh, Pa., are internationally famous as the homes of General Electric and Westinghouse, producers and exporters of many types of electrical machinery.

The production of engines and motors is generally well developed where the demand is greatest, notably in the Soviet Union, Germany, Great Britain, Belgium, France, Italy, and Japan. The British, Swedes, Germans, and Dutch have long been leaders in the manufacture of marine engines. The Swiss, Swedes, and Germans are especially proficient in the manufacture of electrical motors and equipment. Germany, a veritable storehouse of scientific knowledge, gave to the world one of the most useful and economical engines of modern times—the Diesel engine.

3. THE MANUFACTURE OF AGRICULTURAL MACHINERY

The Mechanical Revolution in U. S. agri-

culture. Throughout most of the nineteenth century the United States was blessed with an abundance of cheap farm land and was handicapped by a shortage of labor. Under the old system of man, beast, and simple tools, American farmers could not cultivate as much ground as they could easily secure. Necessity being the sterner mother of invention, Americans came to lead the world in the invention, production, and use of labor-saving farm machinery.

The period from 1830 to 1860 witnessed the invention and improvement of many agricultural implements, such as the steel plow, grain drill, reaper, thresher, mowing machine, hay rake, and corn cultivator, all of these being operated by horse power.[5] These inventions, and many another, greatly reduced human toil in farming, enabling a farmer to cultivate more land and reducing his costs per unit of product. The new machinery proved to be well adapted for use on the vast plains of the United States.

With each passing year, agricultural machinery is improved, and its use becomes more widespread. Old Dobbin is rapidly making his exit, while the tractor and the truck have come to stay. Between 1920 and 1953 the number of horses and mules on our farms declined from 25 to 5½ millions, while the number of tractors increased from 246,000 to 4,400,000. In areas of greatest production of staple crops, the farm horse has become a rarity on road or field. American farmers now own 2½ million motor trucks. In a single decade, 1940–50, the number of tractors and trucks on farms more than doubled, the number of combines nearly trebled, while the number of milking machines and mechanical corn huskers increased nearly fourfold. War prices gave farmer money.

John Rust's mechanical cotton picker is drastically changing cotton production very much as Cyrus McCormick's reaper revolutionized grain production more than a century ago. In 1952 more than 2 million bales of American cotton were picked by machine.[6]

New machines for the farm. Farm machines have been slow in arriving in widely usable form. It may be true that the last 20 years have produced more new types than did the previous 100. Especial mention should be made of machines that (1) turn hard soil into seed bed, (2) make hay, (3) fill the silo, (4) pick cotton, and (5) load trash, lifting up barnyard manure and putting it on the manure spreader.

These machines came late, in part because they had to await miracle steel in the machine shop *and PRICE*. The farmer in the GLUT could not and cannot buy such machines. He had to wait for parity prices.

A tractor-drawn multiple seeder plants five rows of spinach 11 inches apart, and in beds that are bounded by the tractor tracks. This machine then changes into a cultivator that cultivates these five rows of spinach. The crop covers the ground entirely, and is *larger than even hoe tillage could make.*

So-called intensive hand agriculture is on the way out. Men are still leaving the farm for the city as they have for decades. Fewer and fewer men on the farms, with the aid of machinery, are producing more and more.

While the Mechanical Revolution is still going strong, rural robots have not yet inherited the earth. About 60% of all farm work is still done by hand.[7] Nevertheless, U. S. and British farms are rivals in being the most highly mechanized in the world. Therein lies the key to our tremendous productivity. Most European and nearly all Asiatic farms have a high yield per acre. The American farm has a high output per man. In terms of national prosperity, it is the output per man that

---

[5] Successful inventors and businessmen have often been patrons of learning, and college campuses are adorned with many statues in appreciation of past benefactions. Oberlin College has a heroic statue of Charles Martin Hall, appropriately cast in aluminum; Duke University has its James Buchanan Duke, with a cigar in his hand; and Washington and Lee University has Cyrus Hall McCormick, alas, without a reaper.

[6] For an interesting account of the cotton picker, see "Mr. Little Ol' Rust," *Fortune,* December 1952, pp. 150–152 ff.

[7] See "The Machine and the Farm," *Fortune,* October 1948, pp. 97–101 ff.

counts. L. Dudley Stamp, British land-use specialist, says that British agriculture is more highly mechanized than is American.[8]

The western migration of farm-machinery manufacture. Agricultural machinery is very bulky; freight rates are therefore high, giving a great advantage to the factory located as near as possible to the place where it will be used. Therefore, this industry has always kept close to the edge of the great farming region, especially the Grain Belt.

It should be recalled that as late as 1839 about half the nation's wheat was produced east of the Allegheny Mountains, New York, Pennsylvania, Virginia, and Ohio being the leading wheat-growing states. For a time the chief manufacture of farm machinery was near Auburn, N. Y., where the Erie Canal gave easy transportation to both East and West, and in 1830 Pittsburgh led the nation in the manufacture of plows, its product being easily distributed to the markets of the South and Middle West by boats and barges that traversed the vast Ohio and Mississippi river systems.

The manufacture of farm implements followed the westward movement of agriculture. The first great centers beyond the Alleghenies were Columbus and Springfield, Ohio, on the edge of the vast level plain of the Corn Belt, which has been the compelling force to make men use farm machinery. In 1860 the Middle West produced about half of the nation's total output of farm machinery, Ohio and Illinois being the leading states. New England retained leadership in the production of small implements that could be easily shipped to market, such as spades, hoes, rakes, and forks.

With the further westward movement of the market, the industry centered in and around Chicago, the greatest agricultural market in the world, the greatest railway center in the world, with easy access to the greatest corn, oats, hay, and wheat regions in North America. Here are the best facilities in the United States for reaching agricultural districts, and here the great harvester companies located their largest plants. By 1890 Illinois surpassed Ohio in the manufacture of agricultural implements, and it has maintained leadership in the industry until the present day, the value of its output in recent years amounting to over half of the nation's production and more than twice that of Wisconsin, its closest rival.

For decades huge farm-implement factories have operated at Chicago, Ill., Racine and Milwaukee, Wis., and South Bend, Ind. In the last century and early years of the present century these plants obtained wood from the splendid forests of Michigan, Wisconsin, and Minnesota; but with the depletion of these forests, they were forced to turn to the South for their wood supply, some of the larger firms acquiring tracts of forest land. Lake boats helped to make cheap iron. Other farm-implement manufacturing centers developed within the Corn Belt at such points as Richmond, Ind., and Peoria, Ill.

The westward migration of the industry is also shown by the development of important manufacturing on the banks of the Mississippi in a cluster of towns including Moline, East Moline, and Rock Island, Ill., and Davenport, Iowa, in the heart of the Corn Belt, and also Minneapolis, Minn., near the edge of the Spring Wheat Belt. Thus, for well over 100 years the "pull of the market" has been the dominant factor in the location of the industry.

U. S. production and exports. Although approximately 100 firms are engaged in making farm tractors and more than 1000 firms

[8] This may be a shock to some Americans. Dr. Stamp says it is true if you take the number of machines compared to area cultivated. One author says the measure should be the number of mechanical horsepower per worker. Another says it might well be per cent of (1) worker's time used with machine, or (2) area cultivated by machines, or (3) national product cultivated by machines. U. S. Census 1950, Graphic Summary, Vol. 5, p. 6, gives the following for U. S. farms:

(a) no tractor, horse, mule, 1,213,000
(b) horse or mule, no tractor, 1,646,000
(c) horse or mule and tractor, 1,276,000
(d) tractor, no animal, 1,249,000.

Please write. Do tell who is ahead. We want to know.

freight cars are in repair shops being overhauled, and more than 320,000 workers are needed just to keep railway cars and locomotives in repair, or nearly half as many workers as are employed in our great iron and steel industry.

Railway cars. Easy access to steel, coal, and skilled labor, plus the momentum of an early start, have been largely responsible for the concentration of railway car and locomotive manufacture in a few areas.

Chicago is the world's greatest railway center, and more plants for the manufacture and repair of railway cars are located in and around Chicago than in any other district. In Chicago and at nearby Michigan City, Ind., are huge factories that manufacture freight cars. Pullman, Ill., is the world's largest manufacturer of coaches, baggage and express cars, and sleeping, dining, and parlor cars. Since Chicago is the terminus of so many railway lines serving the East, West, and South, many repair shops are needed in the Chicago area.

As Chicago has easy access to the steel of nearby Gary, so the freight-car factories of Butler, Berwick, and McKees Rocks, Pa., are well located near the great steel plants of the Pittsburgh area. St. Louis, Mo., a great railway center with a small but adequate steel industry, is also an important repair-shop center and producer of railway cars.

With the advent of the motor bus, thousands of miles of street-car tracks have been torn up in United States cities, and the manufacture of trolley cars has almost ceased. The picturesque, bone-shaking trolley car has gone the way of Old Dobbin.

In contrast with the standardized production of railway cars, repair work is an individual job. Because of the heavy wear and tear incurred in use, the repairing of cars involves 12 times as many men as car manufacture. The cost of new cars is two thirds the average cost of repairs. Repair shops are usually located at division points along the railroads and in major terminal cities.

Locomotives. Three companies and three places are of predominant importance in the manufacture of locomotives—the American Locomotive Co. at Schenectady, N. Y., the Baldwin Locomotive Co. at Eddystone near Philadelphia, Pa., and the Electromotive Division of General Motors at La Grange near Chicago, Ill. Locomotive works of lesser importance are located at Pittsburgh and Scranton, Pa., and Lima, Ohio.

Locomotives have increased tremendously in size, weight, power, and complexity since the first American-built locomotive, known as the "Tom Thumb," made its trial run at Baltimore in 1830. In contrast with the tiny "Tom Thumb," which weighed less than 1 ton, some modern locomotives weigh as much as 550 tons, contain some 70,000 different parts, and are capable of developing 6500 h.p. at a speed of 110 miles per hour.

Today there are three main types of locomotives—steam, Diesel, and electric. The electric made its appearance in 1895, and since then more than 6300 miles of track have been electrified in this country. Electrification makes flexible power available for use in the smallest of switch engines and the largest of passenger and freight locomotives, which have the advantage of cleanliness, rapid acceleration, regenerative braking, smooth operation at high speeds, and the ability to handle the heaviest of loads over steep mountain grades. The electrification of railroads has proved most profitable in areas where water power is cheap and coal is scarce, as in Switzerland, Norway, Italy, and our own Northwest; and also in areas of great traffic density, as between Washington and New York and between New Haven and New York, and in great terminal areas, such as New York, Cleveland, and Chicago.

In contrast with the electric locomotive, which derives its power from overhead wires or a third rail, the Diesel or oil-electric locomotive is a mobile power plant that converts the heat energy in fuel oil into mechanical energy and thence into electricity. Its power unit can be started and shut off almost as easily as that of an automobile. The Diesel has

all the advantages of the electric locomotive and in this country has proved to be more economical. In 1953 American railroads had 22,570 Diesel locomotives in service, 11,870 steam locomotives, and 700 electrics.

The switch from steam to Diesel is the most drastic change in our railway industry in many years. The first Diesel locomotive was placed in switching service in 1925, but it was not until 1934 that a Diesel was used to haul a passenger train. By 1941 Diesel locomotives were being used in long-distance freight service. Their most recent use is in commuter passenger-train service. As late as 1936 American railroads were buying six steam locomotives for every Diesel that they purchased; in 1952 the ratio was 130 to 1 in favor of the Diesel.[11] At the end of 1953 Diesel locomotives were handling 80% of the nation's freight traffic, 82% of the passenger traffic, and 87% of the switching-yard service.

Production in foreign countries. The Soviet Union ranks second to the United States in the manufacture of locomotives and railway cars. The new locomotive works at Voroshilovgrad in the Ukraine and the car factory at Nizhni-Tagil in the Urals are the largest in the country. Other centers of production in European Russia are Leningrad, Kolomna, Gorki, Bryansk, Mariupol, Kharkov, Sverdlovsk, Dnieprodzerzinsk, and Tiza. In Asiatic Russia the chief centers are Omsk, Tashkent, Svobodny, Chita, and Ulan Ude.

Great Britain, the birthplace of the locomotive, has long been a major producer and exporter of railway cars. Germany, Belgium, and Italy are also important producers.

In most foreign countries government ownership and operation of railroads prevail. During World War I our federal government took over the U. S. railroads and operated them at a loss to the taxpayers of $2 million a day. In World War II our railroads were operated by their owners at a profit, the railroads paying taxes to the federal government that amounted to more than $3 million a day.[12]

[11] Association of American Railroads, *American Railroads, Their Growth and Development,* Washington, 1953, pp. 26–27.

[12] *Ibid.,* pp. 30-31. The rail and water routes of every continent are discussed in Chapters 33 and 34.

26· The Metal-fabricating Industries (continued)

1. THE AUTOMOBILE INDUSTRY

A land of automobiles. Although European in origin, the automobile has become as distinctly American as a baseball game or an order of ham and eggs. The United States automotive industry is the largest and most efficient in the world, with an output three times larger than that of all other nations combined. More than 75% of the world's passenger cars and over 50% of the motor trucks are owned and operated in the United States. Two thirds of all families in this country own automobiles. More than 70 million Americans drive cars, and about 30% of the drivers are women. The number of back-seat drivers has never been ascertained.

About one sixth of the national income is spent on automobiles and their operation. The automobile is exceeded only by food and shelter in the family budget. More than half of all family cars are bought on the installment plan.

The average American ignores the regularity with which the automobile kills him, maims him, and embroils him with the law. He drives his car into the garage with more pride than an Arab chieftain leads a thoroughbred horse into his tent. He woos his car with Simoniz, Prestone, Ethyl, and smooth lubricants. Within a few hours after he has made the last payment on his old car, he goes broke trading it in on a new model. He hopes to progress from a two-door sedan to a hard-top convertible or a ranch wagon, to move up the ladder from a Ford to a Buick and a Cadillac, and eventually to become the proud possessor of a two-car garage. He cannot die happy unless guaranteed delivery to the grave in a Cadillac or Packard hearse. For millions of Americans, the automobile has become the keystone of happiness and the hallmark of success.

In this country the automobile is a creature of mass production, and it has created mass mobility. It has made life easier for millions of working people. It has come to be a symbol of the tragic gap between the American standard of consumption and the subsistence standard in so many foreign lands (see Fig. 14).

A twentieth-century development. The automobile was the result of long experimentation, many minds contributing to its ultimate success. As early as 1865 Siegfried Markus produced a gasoline-driven carriage in Austria, and in the 1880's various improvements were made by Nathan Otto, Carl Benz, and Gottfried Daimler in Germany and by Emile Levassor in France. It was not until 1892–94 that the first successful gasoline-driven motor vehicles were made in this country by Charles E. Duryea, Henry Ford, Ransom E. Olds, Elwood Haynes, and the Apperson brothers. In 1895 there were only 4 motor vehicles registered in the United States; in 1900, about

8000; in 1925, 20,000,000; and in 1954, about 59,000,000. The automobile has grown up in the twentieth century.

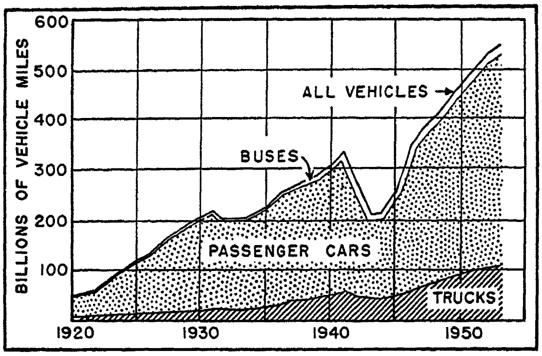
In March 1905 the *New York Tribune* reported that the appearance of two automobiles on Riverside Drive in New York City had made much commotion by scaring horses and gave the names of persons injured in resulting runaways.

The early automobiles were rude adaptations of high-wheeled carriages, into which a one-cylinder gasoline engine was installed. They usually gave more trouble than service. Gradually American engineers improved the motor, the transmission, the chassis, the body, until the automobile became easy to operate, reliable enough to be used day by day by the ordinary individual, and cheap enough to be purchased and driven by the workingman and the farmhand.

Since 1908 cheap and medium-priced cars have been made and sold in such enormous numbers in the United States that today there is one passenger car for every four people. Several million Americans live in trailers, with no fixed abode. More than 7 million children ride to school on buses, and taxicabs carry more than 1½ billion passengers a year. More than 9½ million motor trucks help to move the nation's freight. We have become a nation on wheels.[1]

Location of the U. S. industry. In the strictest sense, motor-car manufacture is not a new industry but rather a successor to the American carriage industry. It was a natural development for the large carriage makers of the Middle West to take up the manufacture of this new kind of vehicle, propelled by a new kind of horsepower, and some of our present-day automobile factories are a continuation of well-known carriage and wagon factories. Thus Studebaker produced wagons and farm machinery long before it turned to the manufacture of automobiles.

The Lower Lake region, with its cheap water transportation and its supplies of heavy metal and wood, is a natural place for this industry. In addition to the marvelous waterway afforded by the Great Lakes, it has also the best of railway transportation, for it is threaded by the various lines connecting St. Louis and Chicago with Philadelphia, New York, Boston, Montreal, and other large eastern cities. This region is also close to the population center of the North American continent, a factor of vital import.

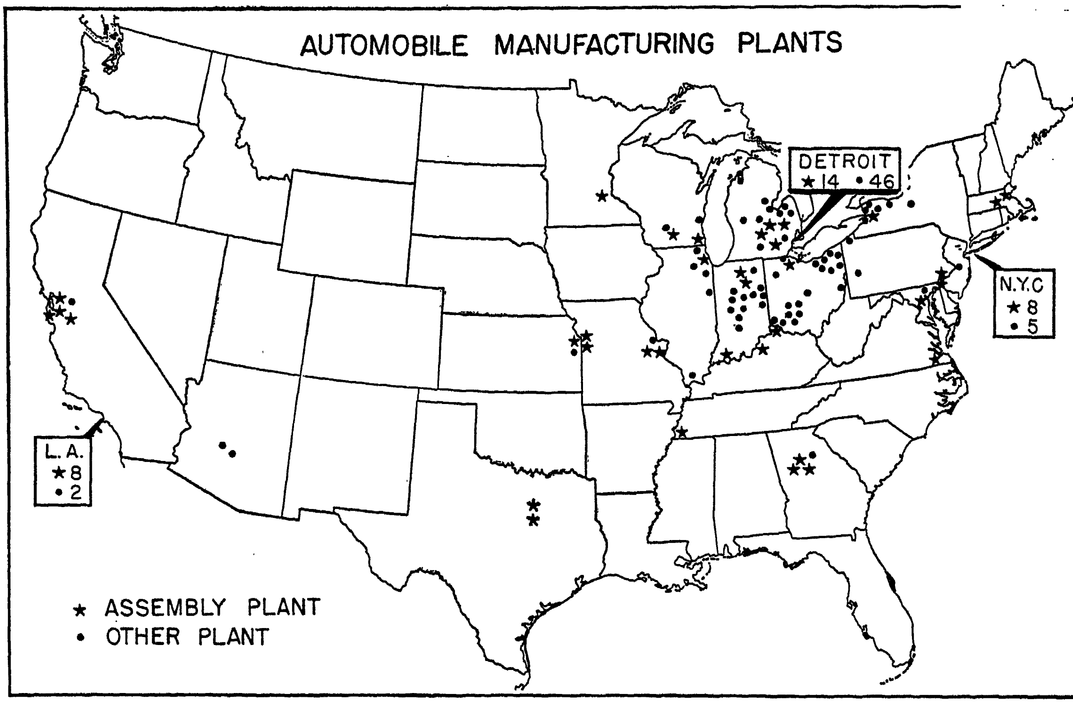


See how steel, pneumatic tires, and oil put a nation on wheels. At 3 persons per vehicle, what is the per-capita mileage? *Automobile Manufacturers Association*

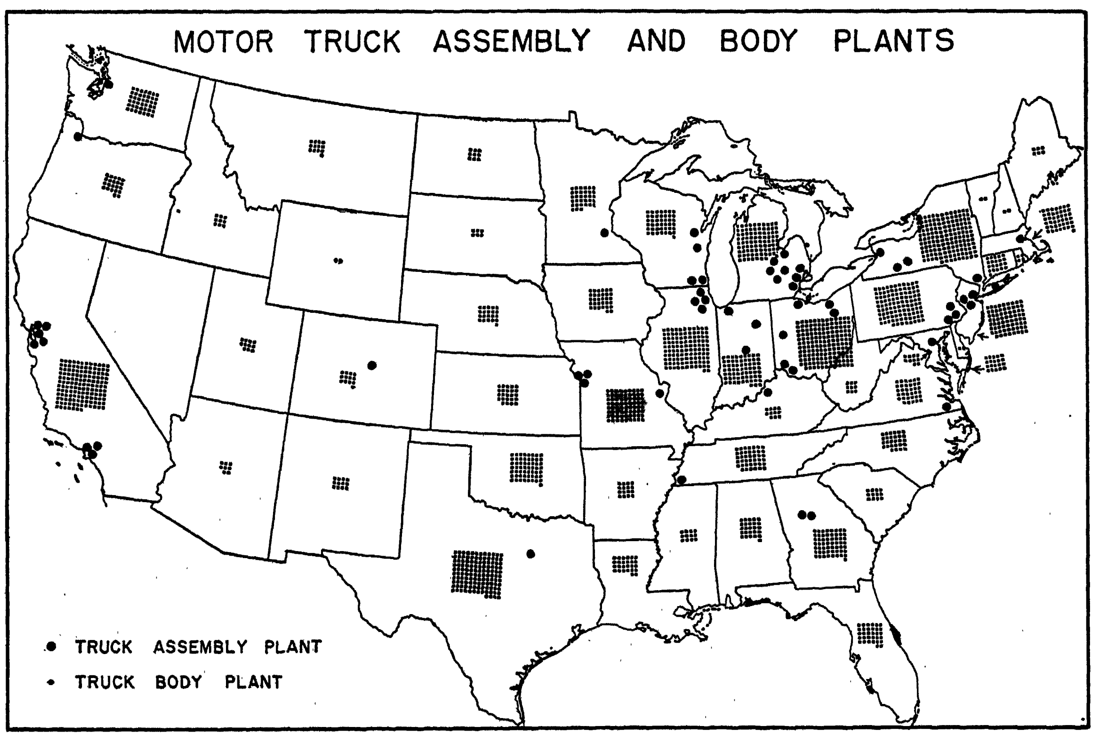
The automobile industry grew up in the midst of a truly great manufacturing region. It was largely historical accident that Detroit became the chief center of production, because Detroit has no advantage of location that does not accrue to Toledo, Cleveland, and a number of other cities. It was Detroit's good fortune that Henry Ford located his factory there—the factory that first used the assembly line, inaugurating the cheap mass production of motor cars.

As the steel industry grew too big for Pittsburgh, so the automobile industry spilled over from the Detroit area, engulfing a number of towns in southern Michigan and adjoining states. Important automobile factories sprang up at Lansing, Pontiac, Willow Run, and Flint, Mich.; Toledo and Cleveland, Ohio; South Bend and Indianapolis, Ind.; Kenosha, Wis.; Chicago, Ill.; and Buffalo, N. Y. Akron, Ohio,

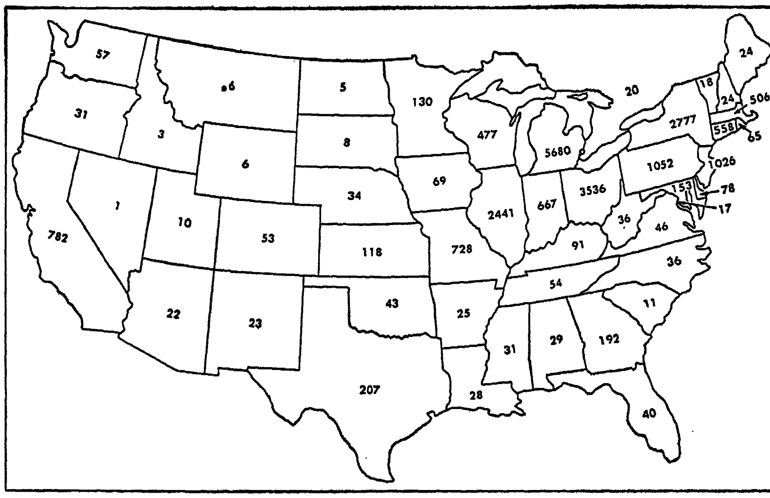
[1] See Automobile Manufacturers Association, *Automobile Facts and Figures, 34th edition—1954,* Detroit, 1954. This is a very informing book.



(*Above*) What is an automobile plant? These company plants "make" automobiles, subassemblies, important parts, but see map of *supply* (Fig. 447) before deciding what is an auto plant. Note assembly plants in population centers. ***Adapted from Automotive News, 1954 Almanac issue.*** (*Below*) Truck bodies tend to fit local needs—fruit, wheat, cattle, lumber, pipe, heavy steel. Three chassis on a truck often go from assembly plant to body plant. ***Motor Truck Facts, 1954 ed.***



Location of 21,074 suppliers of one auto company. See Connecticut and Massachusetts. *Automobile Manufacturers Association*



with its rubber-manufacturing industry, became an economic satellite of Detroit. In terms of value added by manufacture, Michigan now accounts for more than 50% of the nation's output of motor vehicles and parts, while Indiana and Ohio account for nearly 10% each.

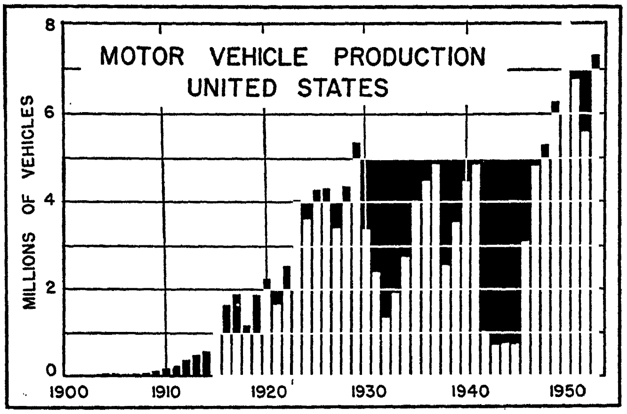
The leading companies, especially General Motors and Ford, have assembly plants scattered throughout the country in proximity to major markets and local pools of skilled labor. Frames, fenders, wheels, engines, and other units are shipped from the main factories to distant plants for assembly. Since the freight rate on a complete automobile is greater than the cost of shipping assembled parts, the manufacturer effects a saving in transportation costs.

U. S. large-scale production methods. While this country produces some of the finest and most costly of motor cars, its greatest achievement has been in standardization and mass production, with its resulting low prices. The early cars were built individually, with parts ground and tooled to fit each other. By the extensive use of automatic machinery, American factories began to make standard wheels, axles, bolts, nuts, bodies, and engines.

Today the manufacture of an automobile involves three major steps in production: designing and engineering, machining, and assembly. About a year before a new model appears on the market, approximately 30,000 man-hours of work are required to design a car, which involves the drawing of many blueprints and the construction of miniature models out of clay and wood, after which the engineers are able to write detailed specifications for all component parts. Then follows the important task of building and installing many special-purpose machine tools to be used in manufacturing the various parts of a car.

Approximately 15,000 parts are used in the manufacture of a modern automobile, and these are either shipped to distant assembly plants or are carried by belt line or overhead conveyors to points within the automobile factory to be combined into nine primary units, including the frame, motor, body, dashboard and steering wheel, gas tank, wheels, and front and rear axles. These primary units are conveyed to the main assembly line, which is a moving platform about 18 inches high that moves forward at a speed of about 18 feet per minute between rows of workmen, each man continuously repeating his small part of the speedy and endless performance.

Production on the main assembly line gets under way when the frame is first placed on the conveyor, and, as it moves along, various parts are added: rear and front springs, rear axle, brake equipment, hydraulic brake tubing, propeller shaft, muffler, and gas tank. A complete engine, which has been built along a tributary assembly line in another part of the factory, swings out on a little crane, drops



400 to 8,000,000, 1900-1950. War shifted men to armament, depression to relief.

upon the moving frame, and is bolted on. The chassis is then painted by spray guns and moves through a drying oven, this being followed by the addition of wheels, steering gear, rear bumper, and rubber body mountings. A complete body, received from a subassembly line, is bolted in place, instruments are connected with the engine, and to the growing car are added running boards or side shields, front bumper, steering wheel, hood hinges, floor coverings, and the hood. Then the gas tank and radiator are filled, the engine is started, headlights are adjusted, the car gets its final inspection and moves off the line under its own power.

Task specialization has been developed to such a minute degree, plant layout has been so well organized, and the assembly process is so efficient that two or three cars or more may roll off the assembly line every minute of the day. On October 31, 1925, the main plant of the Ford Motor Co. established a record when it turned out 9109 Model-T Fords in a single day—more cars than it produced in the entire year of 1908. With increasing output Ford was able to steadily reduce the price of his famous Model-T car from $950 in 1909 to $295 in 1922. Some of these rugged Model-T Fords are still bumping around in the more rural sections of the country.

While the low-priced car now costs about twice as much as in prewar years and is far more expensive than the cars of the 1920's, it is a vastly superior car. The low-priced car of today sells for about 60¢ a pound, which is a lot cheaper than mechanical refrigerators, television sets, washing machines, and even coffee.

The Big Three. Competition has been called the life of trade and the death of traders. The dozens of companies making cars in 1910 and the few that made them in 1954 may serve as an example. The automobile industry is now concentrated in the hands of three big corporations—General Motors, Ford, and Chrysler. In most years these three firms produce 85% to 90% of the nation's passenger cars and 80% to 85% of the motor trucks. The remainder of the passenger-car market is divided between Studebaker-Packard, American Motors (Nash-Hudson), Kaiser-Willys, and a few other producers. The remainder of the truck market is shared by International Harvester, Mack, Brockway, Diamond-T, White, and a few others. As of June 1954, the Big Three accounted for 94% of all automobile sales on the U. S. market, namely General Motors 48%, Ford 31%, and Chrysler 15%.[2]

Ford and General Motors have been able to achieve a high degree of vertical integration, controlling many steps in production from the production and assembly of raw materials to the manufacture and distribution of finished products. Thus Ford makes or can make many of the things that it needs, even paint and glass. The company has blast furnaces at River Rouge near Detroit, using iron ore from its mines and limestone from its

[2] "Autos—Merger No. 3," *Time*, June 28, 1954, p. 84. For detailed accounts of the American automotive industry, see Edward L. Allen, *Economics of American Manufacturing*, Henry Holt & Co., New York, 1952, pp. 285–315; John G. Clover and William B. Cornell (eds.), *The Development of American Industries*, Prentice-Hall, Inc., New York, 1951, pp. 800–833; and Evan B. Alderfer and Herman E. Michl, *Economics of American Industry*, McGraw-Hill Book Co., New York, 1950, pp. 145–173.

TABLE 26:1. Motor Vehicle Registration in Selected Countries, 1953
(thousands)

Country	Passenger cars	Trucks	Buses	Total motor vehicles[a]	Persons per motor vehicle
North America					
United States	46,460	9,609	244	56,313	3
Canada	2,525	850	15	3,390	4
Panama	10	5	[b]	15	54
Mexico	244	163	20	438	61
Haiti	5	2	[c]	7	415
South America					
Uruguay	48	39	2	90	26
Venezuela	109	59	5	173	31
Argentina	257	144	15	416	43
Chile	46	36	4	87	68
Brazil	338	289	23	650	84
Paraguay	2	2	[b]	5	276
Europe					
United Kingdom	2,808	996	70	3,874	13
Sweden	428	106	8	542	13
France	1,832	1,110	28	2,970	14
Belgium	388	157	3	548	16
Switzerland	222	42	2	265	18
Denmark	158	85	3	247	18
Germany, West	1,043	430	20	1,493	32
Italy	614	290	16	920	51
U. S. S. R.	225	2,350	25	2,600	74
Poland	29	46	1	76	328
Rumania	14	10	2	26	610
Yugoslavia	8	18	1	28	612
Asia					
Israel	15	16	2	33	43
Malaya	50	21	2	73	75
Japan	117	528	28	673	127
India	158	88	36	281	1,269
Pakistan	25	8	5	38	1,980
Afghanistan	[b]	4	[b]	4	2,791
China	5	69	6	80	5,800
Africa					
Union of S. Africa	521	142	4	667	19
Egypt	70	16	4	90	230
Ethiopia	5	4	[b]	10	1,910
Oceania					
Australia	1,141	578	8	1,727	5
New Zealand	321	120	3	444	5
New Guinea-Papua	2	2	[b]	4	370
World total	62,501	19,818	739	83,106	29

[a] The sum of passenger cars, trucks, and buses does not always equal world total, as details are not available for all countries.
[b] 500 or less.
[c] Included with trucks.
Source: Adapted from Automobile Manufacturers Association, *Automobile Facts and Figures, 34th Edition—1954*, Detroit, 1954, pp. 30-32.

quarries in the Upper Lake region and coal from its mines in Kentucky. The iron ore and limestone are carried to the factory in lake vessels owned by the company. Ford barges carry finished products down the lakes and through the Erie Canal to New York, and Ford ocean vessels carry cars, trucks, and tractors to Argentina, returning with agricultural products. Throughout this country and in many foreign lands are Ford assembly plants that manufacture cars and trucks from parts shipped from Detroit.

The automobile industry is one of our industrial giants, but despite the "Big Three" its parts are made in thousands of factories in many states. It employs 800,000 workers. The total capital investment of auto makers amounts to at least $5 billion, and since 1948 factory sales of cars, trucks, and buses have exceeded $5 billion a year. The industry has long been known for its high wages and big profits.

Foreign production of motor vehicles. Rising tariffs since World War I have virtually compelled American automobile manufacturers to establish branch factories in major foreign markets. Some of these factories merely assemble parts imported from the United States, while others produce motor vehicles largely or entirely from local raw materials.

European manufacturers turn out some fine cars for the luxury trade, such as the British Rolls-Royce, but low-priced cars are far more important. In 1952 three low-priced cars were competing for first place in western European markets—the German Volkswagen, the French Renault, and the Italian Fiat. The German car sold for $1095, traveled 36 miles per gallon of gasoline, and achieved a top speed of 70 miles an hour from its air-cooled 4-cylinder engine. In 1953 Volkswagen produced 180,000 cars and became the world's fourth largest auto maker.

With an annual output of about 800,000 motor vehicles, Great Britain ranks second in production to the United States. Production occurs chiefly in Coventry, Greater London, Birmingham, Oxford, Abingdon, and Crewe. Coventry, the home of 11 automobile factories, is known as the British Detroit. Great Britain now leads the world in motor-vehicle exports, followed by the United States, West Germany, and France.

Great Britain, Canada, France, West Germany, and the Soviet Union account for about 90% of all motor-vehicle production outside the United States. The principal auto-making centers on the continent of Europe are Paris, France, Wolfsburg in West Germany, Gorki in the Soviet Union, and Turin, Italy. The Canadian automobile industry is concentrated largely in Windsor, across the river from Detroit, and Oshawa, near Toronto.

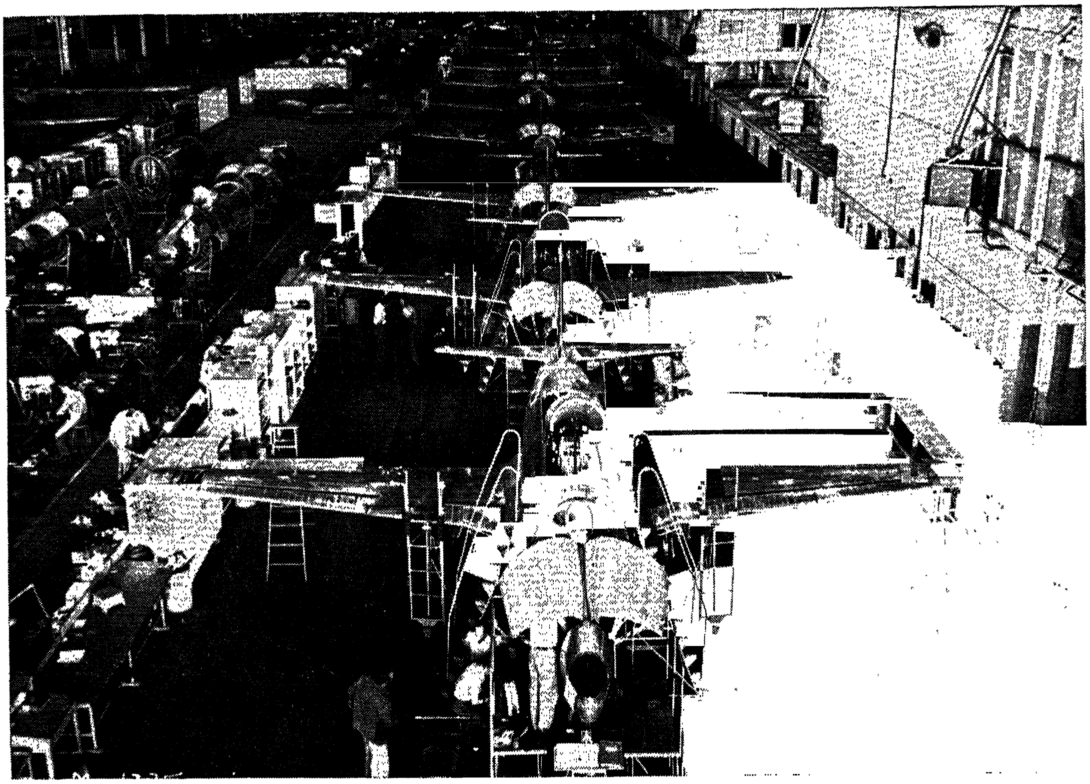
The use of motor vehicles abroad. In the United States there are 3 persons per motor vehicle. Canada, New Zealand, and Australia are the only foreign nations with a comparable ratio (see Table 26:1). In Europe, motor vehicles are most widely used in Great Britain, Sweden, France, Belgium, and other nations of the west. In South America they are most common in Uruguay, Venezuela, Argentina, and Chile. On the African continent the number of persons per motor vehicle ranges from 19 in the Union of South Africa to 1910 in Ethiopia. In Asia it ranges from 43 in tiny Israel to 5800 in mammoth, poverty-stricken China, where mobility as we know it does not exist.

There are not many passenger cars in the countries behind the Iron Curtain. Most of them undoubtedly are reserved for VIPs (very important persons) of the Party.

2. THE AIRCRAFT INDUSTRY

A young and dynamic industry. In contrast with the automobile industry, which achieved maturity in a remarkably short time, the production of aircraft is still in a stage of youthful and rapid development. Technology of manufacture is constantly changing, output fluctuates, and earnings are irregular. Production is more decentralized. The use of aircraft, compared with the railroad and automobile, is small.

Phenomenal progress has been made in the



Airplane assembly line—725 feet one side and down the other, 22 separate assembly stations en route. ***Lockheed***

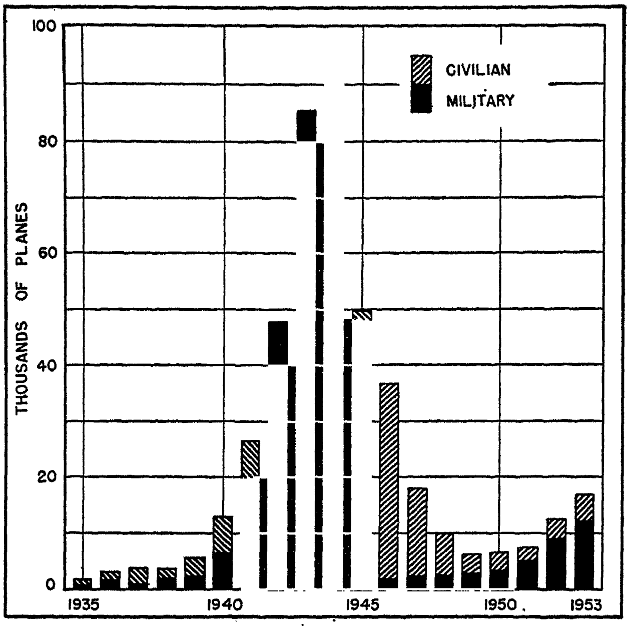
manufacture and operation of aircraft since that cold, historic morning of December 17, 1903, when Orville Wright flew the first successful power-driven airplane for 59 seconds over 40 yards of sandy seacoast about four miles south of Kitty Hawk, N. C.[3] The future of commercial aviation is bright, but who would predict what kind of planes will be produced 10 years from now?

In 1926 only 28 airplanes were engaged in regular scheduled service in the United States. Their average speed was 125 miles per hour, and only 3 of them could carry as many as 10 passengers. International service did not exist. In 1953 our scheduled airlines had nearly 1400 planes engaged in domestic, territorial, and international service. Commercial airliners carrying as many as 80 passengers cruised the skies at speeds of over 300 miles per hour. Military jet planes traveled at twice the speed of sound.[4] Our domestic airlines handled more than 28 million revenue passengers and performed over 270 million ton-miles of express and freight service. About 1.7 million persons traveled by air to foreign countries, as compared with 1.2 millions who went by sea.

Lighter-than-air craft. The production of aircraft involves the manufacture of two types of conveyances, those lighter than air and

[3] Later in the day Orville Wright's brother Wilbur flew the little biplane 284 yards. Both plane and engine had been built and designed by the Wright brothers, bicycle manufacturers of Dayton, Ohio, who had been experimenting with gliders. The tiny internal combustion engine of their craft had a maximum capacity of 16 h.p. and weighed only 107 pounds.

[4] The British were the first to use jet planes in passenger service, operating between London and Capetown and on other long routes. In July 1954 the Boeing Airplane Co. built the first jet transport in the United States, this plane being able to carry 130 passengers at a cruising speed of 550 miles per hour. "Aviation—Gamble in the Sky," *Time,* July 19, 1954, p. 68.



U. S. plane production. The nation hooted when Franklin Roosevelt proposed 50,000 planes a year: 1946 civilian replacement of obsolete. The 1950's rearming. Much more labor on later planes. Employed in 1944: 1,367,000; in 1950, 212,000. *Data from Aircraft Industries Association*

those heavier than air. Lighter-than-air craft include balloons, blimps, and huge rigid dirigibles. For buoyancy and lifting power, the gas bags of these craft are inflated with hydrogen or noninflammable helium. (Virtually all the world's helium supply is obtained from a gas field near Amarillo, Tex., that is a monopoly of the United States government.) While the ballon must wander aimlessly with the wind, blimps and dirigibles are propelled by the power of internal combustion engines. The dirigible is built around a framework of structural steel and aluminum, with control rooms, living quarters, engines, and fuel tanks built into the lower part of the craft.

No dirigibles have been built since World War II. In prewar years most of them were constructed at the Zeppelin works in Friedrichshafen, Germany, and at the Goodyear-Zeppelin plant in Akron, Ohio, and some were made in England.

Nearly all lighter-than-air craft are used for military and naval purposes, although a few dirigibles have been employed in passenger-and-mail services. Since all the power of the motors is used for propulsion, proponents of the dirigible claim that it is more economical in fuel consumption than the cargo airplane for nonstop routes of 2000 miles and that the saving in fuel would increase for longer distances.

The helicopter. Infant prodigy of aeronautical science is the helicopter, which was perfected just prior to World War II. This wingless craft, often called the "flying windmill," the "whirligig," or the "egg beater," depends upon a rotary vane above the fuselage for its lifting power and maneuverability. It is the only aircraft than can move up, down, forward, backward, and sideways under its own power and control. When equipped with pneumatic floats, it is the only aircraft that can light on or take off from water, ice, snow, mud, marsh, or dry land with no adjustment in landing gear. It requires only a few square feet of landing space.

Because of its unusual maneuverability, the helicopter saved hundreds of lives on Korean battlefields. It moved troops and supplies into rugged areas, proved valuable for reconnaissance, and at times was used to direct artillery fire.

In Great Britain helicopters are used to maintain aerial bus service between London and Birmingham. In some metropolitan areas they deliver passengers from outlying airports to downtown terminals. New York City now has helicopter service between La Guardia, Idlewild, and Newark airports. In Los Angeles, Chicago, and New York helicopters are providing mail service to nearby communities. Oil and gas companies use them to patrol pipelines and to deliver pipes to remote areas. Some farmers use them to dust crops with insecticides.

In 1952 a helicopter made a record 1234-mile nonstop flight from Fort Worth, Tex., to Niagara Falls, N. Y., in 12 hours and 57 minutes. In the same year the first helicopter

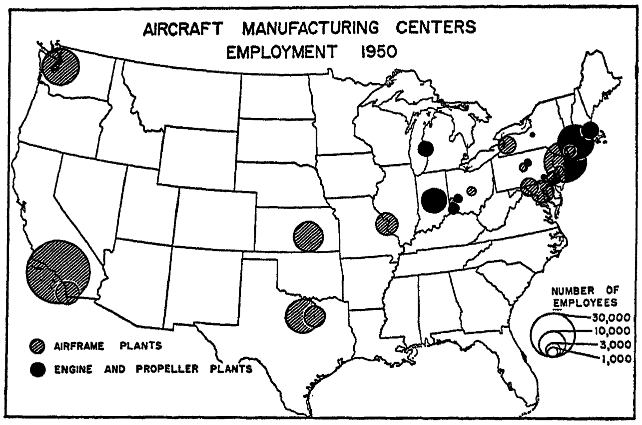
crossed the Atlantic via Labrador, Greenland, Iceland and Scotland.

Some of the new models can carry 40 passengers more than 300 miles. Erelong the helicopter may help relieve the traffic congestion that has about reached the saturation point on the motor buses and suburban trains serving metropolitan areas. Eventually it may play an important role as a vehicle of individual transport comparable to that of the motor car.

Airplane manufacture in the United States. It is the airplane, however, that dominates the aviation industry of today and that has made possible the establishment of commercial airline routes across the continents and oceans of the world. So revolutionary has been this development that mankind's geographical thinking in terms of time and distance has been revised almost overnight. In the development of commercial aviation the United States, with its speed-minded people and long distances of travel, has led the world.

Many diverse types of airplanes are now produced to meet the varied demands of military, naval, commercial, recreational, and scientific services. Huge transport planes are now commonly used in long-distance national and international services for the transportation of passengers, mail, and express. Smaller planes are employed on shorter routes and for taxi and charter services. Special types of craft are needed for photography, aerial surveying, forest patrol and fire fighting, crop dusting and spraying, and commercial advertising. The production and commercial use of airplanes and gliders for freight service is just getting under way.

American aircraft production boomed during World War II, reaching an all-time peak of 96,318 planes in 1944. For three years, 1942–44, our entire output was destined for military use. In 1953 our plants produced 12,000 military planes and 4700 planes for civilian use. More than 500,000 aircraft have



The complex engine stays in the older industrial area. ***Data from W. G. Cunningham, The Aircraft Industry, Los Angeles, 1951***

been built in this country to date[5] (see Fig. 452).

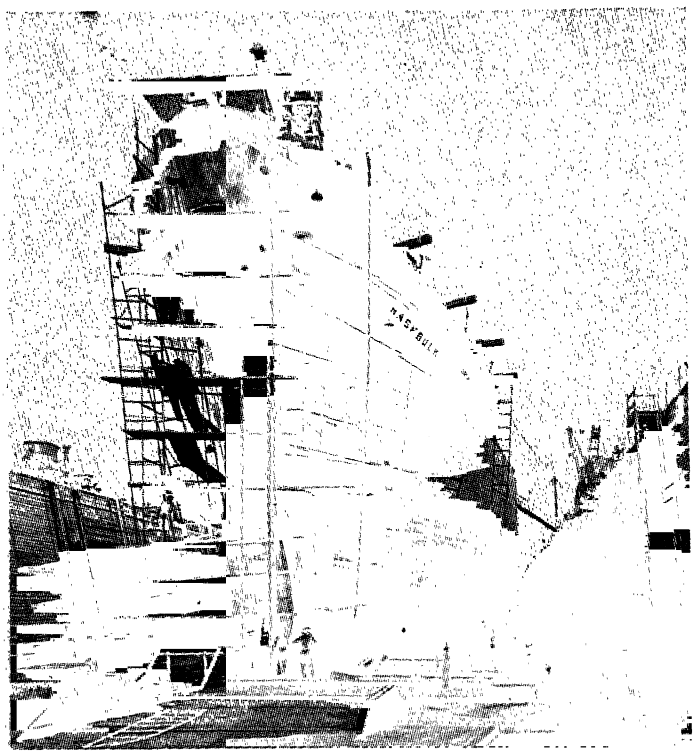
Practically all military and commercial airplanes are produced by 15 companies. In 1953 five firms led the industry in plant capacity, or floor space for the assemby of airplanes—Douglas, Boeing, Consolidated Vultee, Lockheed, and North American.

California is by far the leader in the assembly of airplanes, with plants at Santa Monica, El Segundo, Long Beach, San Diego, Burbank, Hawthorne, and Los Angeles. These plants in sunny southern California have the advantages of clear flying weather for year-round test flights, warm and dry weather permitting much outdoor work, and generally mild temperatures that reduce the cost of heating buildings. Texas ranks second in airplane assembly, with plants at Fort Worth and Dallas. Other leading centers of production are Wichita and Kansas City, Kans., Farmingdale and Bethpage on Long Island, N. Y., Seattle, Wash., and Baltimore, Md.[6] (see Fig. 453).

The mass-production achievements of the automobile industry have not been duplicated in airplane manufacture, which as yet remains a job-lot type of production employing quasi-assembly-line methods. Mass production of

[5] Aircraft Industries Association of America, Inc., *Planes,* April 1954, p. 1.

[6] See William G. Cunningham, *The Aircraft Industry: A Study in Industrial Location,* Lorrin L. Morrison, Publisher, Los Angeles, 1951.



The largest of his creations that man can move. Large tanker in drydock, Hoboken, N. J. Water will be admitted, gates removed, and the ship floats away. *Bethlehem Steel Co.*

airplanes has been retarded by the limitation of the market, the great variety of models, constantly changing design, inability to use automatic tools in many tasks, and the large number of inspections of workmanship that are necessary. The auto maker produces tens of thousands of a single type. Furthermore, the airplane assembly line is not moving continuously. For example, in the assembly of the fuselage, approximately 20 work stations are needed, and the main assembly line halts for several hours at a time while workers at each station install unit assemblies or subassemblies on each fuselage in various stages of completion. Hence, while 2 or 3 Fords, Plymouths, or Chevrolets may roll off an automobile assembly line every minute of the day, only 1 to 10 airplanes, depending upon the type of plane and the size of the order, come off an assembly line in one day (see Fig. 451).

Foreign production. In the Soviet Union both the production and operation of aircraft are owned by the government, and in other foreign countries they have received generous governmental aid because of their strategic importance in time of war. It is from U. S. and European manufactures that other countries obtain most of their commercial and military aircraft.

The Soviet Union leads all foreign nations in aircraft production, which is located chiefly in the Moscow-Gorki, Ukraine, and Ural industrial areas, with lesser centers at Novosibirsk, Tomsk, Sverdlovsk, and Kosomolsk in Asiatic Russia. In western Europe the leading centers of production are London, Coventry, Wolverhampton, Bristol, and Southampton in Great Britain; Paris, France; and Milan, Italy. Aircraft manufacture has been prohibited in West Germany since World War II.

3. SHIPBUILDING

How ships are built. The ship is too large an object to be made on a moving assembly line. The demand for ships in normal times is too small to permit the manufacture of parts by mass-production methods. The purchaser places an order with the shipbuilder and specifies in great detail the type of ship desired. These specifications depend upon the type and amount of cargo to be carried, the type of engines and speed desired, the length of voyages to be traveled, the port and climatic conditions to be encountered, and many other factors. Except in times of war, when ship types are standardized to permit speedy production, the ship is distinctly a custom-built or tailor-made job.

A model life-sized hull is first laid out on the floor of the mold loft with wooden or composition templates, or mock plates. These serve as patterns in the shipyard's plate and angle shop, where steel plates are sheared, punched, countersunk, and bent to conform to the templates. Construction of the ship occurs on the "way" or foundation, upon which scaffolding is erected to support the hull and from which the completed ship is allowed to slide

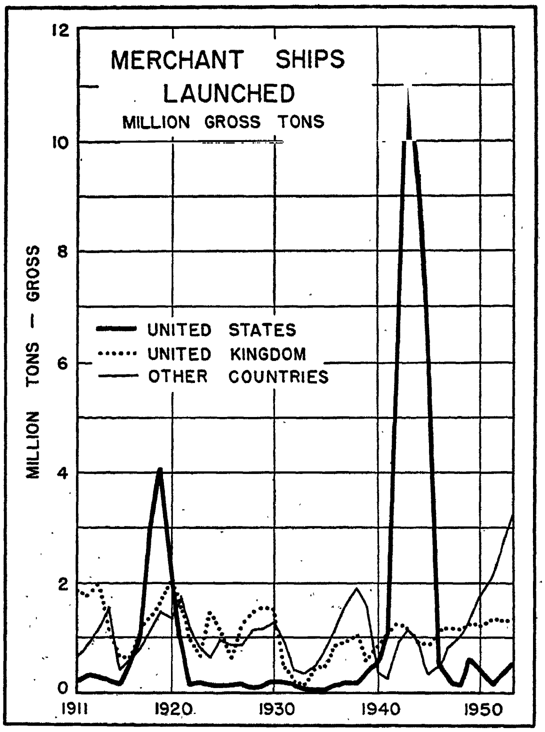
into the water. Construction begins with the laying of the keel plates, or steel plates laid in tiers. Then comes the vertical keel, or ship's backbone, a long girder that extends through the full length of the hull. Huge plates for the ship's bottom are attached to the keel. Longitudinal girders are bolted into position, followed by transverse frames, bulkheads, sides, and deck.

In general, work begins amidships and proceeds in all directions, but the hull grows steadily upward like any building under construction. Before the hull is completed, the masts, engines, and heavy machinery are installed. When the ship is ready for launching, the keel blocks are removed, and the ship slides into the water with a mighty splash. Tugboats tow the vessel to the fitting basin, where interior painting, plumbing, small hardware, and electrical fixtures are added, but in Europe a vessel is seldom launched until absolutely complete. If the ship fulfills all requirements on its trial run, it is ready for delivery to the purchaser.

The method of ship construction shows the necessity of locating shipyards upon deep, quiet rivers or bays with an abundance of available land along the shore. All the important shipbuilding localities are near steel-manufacturing districts.

British leadership in shipbuilding. Great Britain has long led the world in shipbuilding, and as late as 1893 her shipyards launched four fifths of the world's merchant vessel tonnage. With the development of shipbuilding in other countries, the British share of the world's output declined. In 1953 British shipyards accounted for 25% of the gross tonnage of newly launched merchant vessels, as compared with 34% in 1938 and 60% in 1913 when Britain was mistress of the seas.

Britain's leadership since the latter part of the nineteenth century is due partly to unusually cheap iron and steel produced close to the sea, partly to cheaper skilled labor, partly to the availability of capital and the limitations of home opportunities, partly to the habit of seamanship and to long experience in



The German submarine was the greatest stimulus that shipbuilding ever had. Result, remarkable. ***Data from Lloyd's***

shipbuilding, but also largely because the great British Navy and merchant marine furnish a truly large demand for ships. During and shortly after World War I, and again during World War II, Britain temporarily lost her shipbuilding supremacy to the United States, when American yards broke all shipbuilding records with mass production of standardized ships. In the postwar era Britain has come to lead the world again (see Fig. 455).

While shipbuilding is carried on in many areas, the northeast coast of England, centering about Newcastle-on-Tyne and Sunderland, and the Clyde estuary below Glasgow, Scotland, generally produce about four fifths of all British merchant tonnage. Along the northeast coast more than 40 companies build all kinds of ships but specialize in the construction of tramps, cargo liners, tankers, and war vessels. The Clyde region, with more than 30 shipbuilding firms, concentrates largely on passenger liner and naval construction, and

here were built the great super-liners *Queen Mary* and *Queen Elizabeth.*

Other important shipbuilding centers are to be found in Northern Ireland at Belfast on the deep Lagan estuary and along the west coast of England at Birkenhead on the lower Mersey and at Barrow-in-Furness. Small craft are built along the shallow estuary of the Dee, and fishing boats are produced along the Humber. At Portsmouth, Devonport, and Chatham the Royal Navy operates yards for the construction and repair of war vessels. Many a British harbor, little more than a hole in the mud served by the dredged channel of a small stream, is the site of a thriving shipbuilding industry.

Not only do British shipyards build new ships for the merchant marines of many nations, but each year British shipowners sell old ships to shipowners in Japan, Italy, Greece, Spain, and other countries, some of these ships having a total lifespan of 25 to 40 years. With the exception of a few Great Powers, the navies of many foreign countries depend upon British yards for their vessels. Hence, British-built ships fly almost every flag upon the sea.

Development of shipbuilding in other foreign countries. In prewar years Germany usually ranked second only to Great Britain in shipbuilding, German shipyards at Stettin, Rostock, Lübeck, Kiel and Hamburg turning out some of the finest ships afloat. At the conclusion of World War II, as after World War I, Germany was required to turn over virtually all her merchant marine to the victorious Allies in compensation for the wartime sinking of Allied ships by German submarines. At the end of World War II severe restrictions were imposed upon German shipbuilding. In April 1951 these restrictions were lifted, and Hamburg is again busy building merchant vessels.

The Netherlands, Sweden, and Denmark—small but important maritime nations—have long had flourishing shipbuilding industries, using steel imported from Germany and Great Britain. Dutch yards at Rotterdam and along the North Sea Canal, Danish yards at Copenhagen, and the Swedish yards at Göteborg and Malmö often turn out more merchant tonnage than is produced in France and Italy.

In France shipyards are located at the Atlantic ports of Cherbourg, Le Havre, and Bordeaux and at the Mediterranean ports of Marseilles and Toulon. In Italy the ports of Genoa and Naples are the chief shipbuilding centers. In most years the output of French and Italian yards is less than 10% of that of the British.

In the Soviet Union ocean-going vessels are built at Nikolayev and Sevastopol along the Black Sea, at Leningrad on the Gulf of Finland, Murmansk on the Barents Sea, Archangelsk on the White Sea, and Vladivostok on the Sea of Japan. Most Russian merchant vessels are used in domestic trade between the nation's widely scattered seaports.

In prewar years Japan, like Germany, had an important merchant marine and shipbuilding industry which suffered heavy losses during the war. Kobe and Nagasaki are the leading shipbuilding centers. In 1953 Japan ranked second among all nations in the construction of merchant vessels.

Governmental aid to U. S. shipbuilding. Virtually all maritime nations, with the notable exception of Great Britain, protect their shipping and shipbuilding industries by laws excluding foreign vessels from participation in the coastal trade. Since 1817 the American coastal and inland-water trade has been restricted to ships built and owned in the United States.[7] Federal law also requires all vessels for our navy to be built in this country.

In the United States modern shipbuilding is a high-cost industry flourishing under the

[7] This reservation now applies not only to all water-borne traffic between ports within this country, including the large intercoastal trade between our Atlantic and Pacific seaboards, but also to trade between continental United States and Puerto Rico, Alaska, Hawaii, Guam, Tutuila, and American Samoa. Since 1912 foreign-built ships have been admitted to U. S. registry, but as these ships are limited to foreign trade, American shipowners prefer American-built vessels that are permitted to engage in any trade.

abnormal demands of war and languishing during the long interims of peace. The inability of American shipbuilders to achieve the low costs prevailing in foreign shipyards is partly owing to our methods, partly to the higher cost of materials, and especially to the higher cost of American labor.

The normal practice of using special designs and equipment in the construction of American ships materially enhances their cost. While British shipyards are often able to reap some of the economies of large-scale production by laying down in adjacent ways the keels of six or more nearly identical vessels at one time, U. S. shipyards seldom have on hand the orders to permit building more than one ship at a time. Although the f.o.b. mill price of steel plates and structural shapes is as low in this country as in Great Britain and Germany, most of our leading iron and steel centers are located much farther from tidewater, and these vital materials are burdened with higher transportation costs en route to the shipyard. Above all, shipbuilding is not adapted to assembly-line methods and requires a vast amount of skilled labor, and U. S. wage rates are much higher than those abroad. Indeed, labor represents about 45% of the total value of an American ship.

The handicap of high shipbuilding and ship-operating costs to the development of our merchant marine was recognized by Congress when it passed the Merchant Marine Act of 1936, authorizing the grant of construction and operation subsidies. Under this act our shipowners are compensated for the difference between the cost of operating a vessel under the American flag and what it costs competing companies to operate under foreign flags on those routes considered to be of importance to the foreign commerce of the United States. The government also pays the difference between the cost of building a ship in an American shipyard and the estimated cost of building a vessel of the same design abroad. Furthermore, ships can be paid for under the installment plan.

The passenger liner *America* measuring 26,482 gross tons, would have cost $10,500,000 if it had been built in a Dutch shipyard. The vessel was built at Newport News, Va., at a cost of $15,750,000, the federal government paying one third of the cost. The new superliner *United States* is a vessel of 53,329 gross tons and is the fastest merchant vessel afloat.[8] It was built at Newport News at a cost of $70,000,000, the federal government contributing $42,000,000.

The location of U. S. shipbuilding. Fully two thirds of our total merchant vessel tonnage is normally built in shipyards that cluster about the spacious waters of New York harbor, the Delaware River and Bay, and Chesapeake Bay. Among the leading yards in the New York area are those of Staten Island, Brooklyn, and Kearny, N. J.

The Delaware, sometimes called the American Clyde, with yards at Philadelphia, Camden, Chester and Wilmington, is the most important shipbuilding river in America. The Clyde is but a creek dug out at great cost, while the Delaware is a wide, open estuary with room enough to build the shipping for all the world.

Along the Chesapeake Bay are great shipyards at Sparrows Point near Baltimore and at Newport News at the mouth of the James River. All types of merchant vessels and some of the world's largest battleships are built in this Middle Atlantic shipbuilding region, which has a large supply of skilled labor and which obtains its steel from Sparrows Point

[8] From the tip of its bow to the end of its fantail, the *United States* is 990 feet long, and its beam of 101½ feet is just narrow enough to squeeze through the 110-foot-wide locks of the Panama Canal. Its oil-fired boilers and high-pressure steam turbines develop more than 165,000 h.p. In times of peace it carries 2000 passengers and a crew of 1000, but it has a wartime capacity of 14,000 troops with equipment. The vessel is insured for $31 million, the highest value ever placed upon a merchant ship. Although smaller, shorter, and narrower than the *Queen Elizabeth* and *Queen Mary*, she is faster, with an undisclosed maximum speed. In 1952 the *United States* crossed the Atlantic in the record time of 3 days, 10 hours, and 40 minutes, a distance of 2938 miles at an average speed of nearly 36 knots.

and from the Pittsburgh area, its machinery and engines from factories and shops of the East, and its coal from Appalachia. In most years Newport News is the nation's leading shipbuilding center.

New England lost her shipbuilding supremacy when wood gave way to steel in hull construction. Many types of large vessels are constructed in the modern shipyard at Quincy, Mass., smaller craft being built at Groton, Conn., famous for its submarines, and at Bath and South Portland, Maine. Since much of the work of shipbuilding occurs out of doors, New England yards are handicapped by interruptions caused by heavy snow, ice, and bitter cold in winter.

Although the Gulf and Pacific coasts have climates conducive to year-round shipbuilding activity, neither region has developed an important shipbuilding industry in times of peace. Both regions are handicapped by limited steel-making facilities and by distance from major steel centers. Among the principal southern shipyards are those of Tampa, Fla., Mobile, Ala., Pascagoula, Miss., and Beaumont, Tex. On the Pacific Coast, Seattle, Wash., Portland, Ore., and San Francisco, Calif., are the leading shipbuilding centers.

Shipping upon the Great Lakes renders great commercial service and the vessels, being so large that they cannot leave lake waters, are built upon the lake shores. The most important centers are at Cleveland, Chicago, Detroit, and Buffalo, although there is some shipbuilding at the Lake Erie ports of Lorain and Toledo.

United States navy yards. The enlarged Navy of the United States requires government navy yards equipped for the repair of war vessels. As these repairs are often extensive, some yards are now able to build—and they have built—battleships and should therefore be ranked among the important shipbuilding enterprises of the United States. They are located at Portsmouth, N. H.; Boston, Mass.; Brooklyn, N. Y.; Philadelphia, Pa.; Norfolk, Va.; Charleston, S. C.; Bremerton, Wash.; and Mare Island, Calif.

Wartime and postwar shipbuilding in the United States. The need of building ships fast enough to beat the submarine made standardization of shipbuilding in the United States an absolute necessity throughout World War II. By minutely standardizing the vessels and limiting them to a few types, the builders were able to use the machine shops of the whole nation, rather than remaining dependent upon works near the shipyard.

Thousands of duplicate parts were manufactured for hundreds of duplicate ships. Like knockdown houses, parts of vessels were made all over inland America, partially assembled, delivered at the shipyards, and put together with all possible speed. Certain firms, in fact, were able to construct as much as 50% of a Liberty cargo ship off the ways. Never before was labor-saving machinery used on such an extensive scale.

Outstanding product of standardization during World War II was the Liberty ship, or "ugly duckling," that was modeled after a modern British tramp, being designed for capacity rather than speed. This practical seagoing "truck," capable of carrying 10,500 tons of cargo at a speed of 11 knots, was easy to build, operate, and repair. Some of these ships were completely built in less than 7 days.

During the war years of 1942–45, American shipyards built 4915 merchant vessels totaling 36,960,000 gross tons, consisting of 4070 cargo vessels (including 2710 Liberty ships), 720 tankers, and 125 passenger and passenger-cargo vessels. In addition our shipyards turned out naval vessels, transports, landing craft, and many other types of ships for the Armed Forces. No other nation ever built so many ships in such a brief span of time (see Fig. 455).

In the postwar years of 1946–52, U. S. shipyards built more than 100 tankers for the petroleum industry, 18 passenger and passenger-cargo vessels, 22 dry-cargo vessels for American shipping lines, and 35 cargo vessels for the government. In contrast, other maritime nations added more than 2700 merchant vessels to their fleets. Of 1500 ocean-going

Sharp eyes, magnifying glasses, and skilled fingers are increasingly used in electronics and other exact metal manufactures. Watchmaker at right is making a jewel setting. *Raytheon Manufacturing Co., Waltham, Mass., and Waltham Chamber of Commerce*

merchant vessels under construction throughout the world in 1952, only 80 were being built in United States shipyards.[9] In January 1954 our shipyards had only 40 vessels under construction. Feast and famine with war and peace has been the general rule in American shipbuilding throughout the present century.

4. SMALL METAL MANUFACTURES

The importance of skilled labor. An inspection of a hardware store reveals a collection of hundreds and even thousands of articles, such as saws, axes, cutlery, firearms and ammunition, radio sets, plumber's, tinner's and carpenter's tools, and that very long list of articles known as builders' hardware, nearly all of which are made of metal. A jewelry store reveals a collection of still more valuable metal products in which, as in all hardware, the metal plays a relatively small part and the labor a large part in the cost of production. This high labor and small material value means that these articles are likely to be produced where population is abundant, labor is skilled, and manufactures well established, as in New England or northwestern Europe, not where they are scarce, as in Nevada, Arizona, or the Dakotas.

The distribution of the industry. New England, the home of "Yankee notions," has long been the American leader in the production of a great variety of small metal products. Thus the city of New Britain, Conn., produces about one tenth of the nation's hardware. Springfield, Mass., and Bridgeport, New Haven, and Hartford, Conn., normally make about two thirds of all firearms. The fine scales of St. Johnsbury and Rutland, Vt., are used to weigh goods all over the country, while the watches and clocks of Connecticut and

[9] Of the privately owned merchant vessel tonnage under the American flag on January 1, 1952, 83% was warbuilt, 9% was postwar, and 8% was prewar tonnage. It contrast, 34% of all foreign merchant vessel tonnage was warbuilt, 26% was postwar, and 40% was prewar tonnage. See "Stormy Weather," *Time,* March 24, 1952, pp. 93–96, and Committee on American Shipping Lines Serving Essential Foreign Trade Routes, *What's the Score in American Shipping?,* New York, 1953.

Massachusetts have helped to keep Americans on time for the last 150 years. Fully one third of the nation's jewelry is made in the Providence-Fall River-New Bedford area. Recently New England has made great progress in the manufacture of electronic devices.

That New England is able to retain her leadership in small metal manufactures is owing partly to Yankee skill and ingenuity, partly to the impetus of an early start, and very largely to the fact that the varied products of this industry require much skilled labor and little raw material and that the small, high-valued finished products are easily able to stand high transportation charges to many markets.

The United States is seldom at a disadvantage in small metal manufacturing so long as it involves the use of power-driven machines, assembly lines, interchangeable parts, and standardized products. Every year large numbers of American-made typewriters, business machines, electric clocks and razors, dishwashers, refrigerators, vacuum cleaners, washing machines, and other products are exported to foreign lands. Much of this export rests in part on patents. What will happen when patents expire is open to speculation.

When *cheap* skilled labor is the decisive factor, Europe or Asia has the advantage. The importance of this is shown by recent developments in the American watch-manufacturing industry. Between 1938 and 1950 the number of uncased jeweled movements exported from Switzerland to the United States increased from 2,219,000 to 5,629,000, while the export of complete jeweled watches increased from 116,000 to 1,951,000. By 1950 complete watches accounted for 26% of Swiss shipments to this country. In 1950 American watch manufacturers using only domestic materials supplied about 25% of our consumer demand, while watch assemblers supplied about 75%. In 1954 Hamilton, Elgin, and Waltham clamored for a higher tariff, while Gruen, Bulova, and other large importers of Swiss watch movements were opposed.[10]

Hundreds of small metal products have achieved world fame because of the painstaking skill used in making them. Among them are the fine watches of Geneva, Switzerland, and the cutlery of Sheffield, England, and Solingen, West Germany. Americans have never thought of establishing a wood-carving business; it belongs in Europe just as the more difficult ivory carving and lacquer work belongs in the Far East, where manual skill is cheapest. Likewise, a large portion of the world's simple toys are made in Japan.

Some small metal manufactures are not quality products. A few years ago a German salesman noticed that almost every native hut in a section of Africa possessed an alarm clock made in England. The natives could not tell time, but the louder the clocks ticked and the louder the alarms rang, the better the natives liked them. The salesman meticulously reported this fact to executives in his factory in Germany. Erelong a German clock manufacturer captured the market with a cheap clock that contained few works, did not keep time, but was twice as loud as the English clocks.

[10] American Watch Association, Inc., *United States Tariff Commission, Brief in Behalf of American Watch Association, Inc.,* New York, July 1951, pp. 6, 10, and "The Watch Tariff," *Time,* July 12, 1954, pp. 81–82. And then in July 1954, the President of the United States used his authority for flexible tariffs to raise the tariff on Swiss watches, despite the many predictions of bad influence on European public opinion. This was during a period of Point Four giving by the U. S. government. Europeans had repeatedly said, "We want trade, not aid," but the President checked the trade and continued the aid.

27· Chemical Raw Materials and Manufactures

1. CHEMISTRY IN THE LABORATORY AND FACTORY

Research: the keystone of progress. We are living in an era of chemical discovery that ultimately may be as revolutionary, perhaps even more revolutionary in its industrial consequences, than the Mechanical Revolution which resulted from a new, larger, and better use of energy. The Chemical Revolution now under way arises from a deeper understanding and a more effective use of matter.[1]

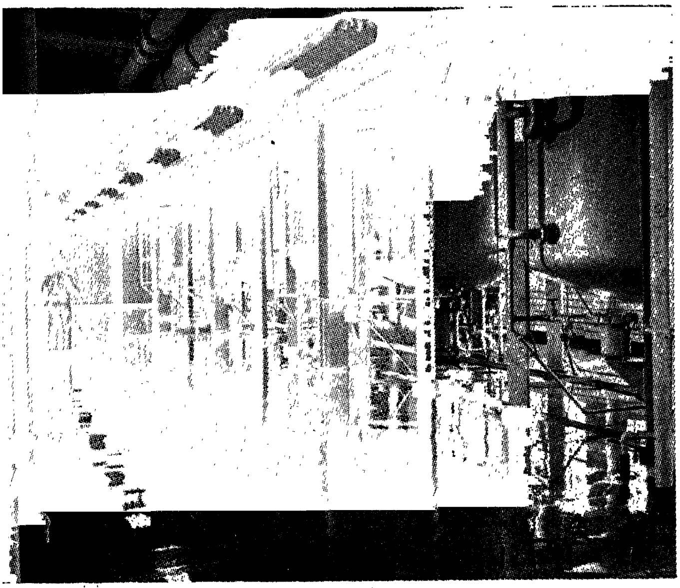
Key man in this new revolution is the research chemist who, by the use of such forces as heat, light, pressure, and electricity, is able to break down existing combinations of molecules and atoms and rearrange them in new combinations. As a result of research costing many millions of dollars a year, there emerges from the chemical laboratories of today an endless and increasing stream of new products and new processes of manufacture. Chemical research is constantly bringing about the creation of entire new industries and vital changes in others, while for some industries it means competition and utter ruination.

We learn by trial and error, and the industry that neglects research is doomed to stagnation and decline. So important is research that the American chemical industry spends 2½% of every sales dollar for research. It employs 651 research workers for every 10,000 workers engaged in production, as compared with 133 per 10,000 for American industry as a whole.[2] There are now over 700,000 chemicals listed. The products of the chemical industry cover a vast range, from fertilizers for the field all the way to drugs, medicines, vitamins, and perfumery. The number of its products doubtless outnumbers that of all other industries combined.

Theory transformed into practice. The chemist knows from experience that many a promising discovery in the laboratory is not always practical under conditions of large-scale production. When the apparatus is enlarged to factory size to handle large masses of raw materials, many unexpected troubles appear. The chemical engineer takes over. After a new product or process has passed its laboratory tests, the chemical manufacturer may build a small factory, or pilot plant, in order to ascertain the effects of production on a semicommercial scale and to make whatever readjustments are necessary. Thus, without

[1] "The Chemical Century," *Fortune,* March 1950, pp. 69–76, and Williams Haynes, *Men, Money and Molecules,* Doubleday, Doran & Co., Inc., Garden City, N. Y., 1936.

[2] Manufacturing Chemists' Association, Inc., *The Chemical Industry Facts Book,* Washington, 1953, pp. 57–58.



Double row of 5000-gallon tanks: liquor grows mold to make penicillin. *Upjohn Co.*

tying up too large an investment, much of the vital "know-how" of production is learned. Finally, the new product or process is ready for large-scale production, which is conducted by less skilled workers who merely follow standard instructions that have been carefully prepared by the chemical engineers and laboratory technicians.

One of the greatest achievements of the American chemical industry has been the development of the continuous process, permitting large-scale operations and resulting in a saving in time, a more uniform product, and smaller losses in production. Almost every day some new molecular combination is discovered or some new set of chemical reactions is so perfected that another laboratory process may become an industrial process, with the result that the prices of many chemical products are rapidly declining and the output rapidly increasing. Nowhere have the tools and techniques of modern science been brought to bear more effectively than in the chemical industry. The assembly line of hard materials is replaced by the continuous flow in which the operator turns valves and watches indicators, with manual labor at a minimum.

2. THE RISE OF THE CHEMICAL INDUSTRY

Early British and German leadership. Of all the tools or agents used by the chemical industry, the most essential are acids and alkalies, and of these none is of greater importance than sulfuric acid and soda ash. The first great stimulus to chemical manufacture occurred when the textile industry moved out of the home into the factory. The large-scale production of textiles by power-driven machinery greatly increased the demand for sulfuric acid and soda ash needed in the manufacture of soap, bleaching powder, detergents, and dyes.

Fortunately, two outstanding developments enabled chemical manufacturers to meet the growing demand. One was the beginning of sulfuric-acid production on a commercial scale in a lead-chamber process plant established by John Roebuck at Prestonpans, Scotland, in 1749. The other was Nicolas Le Blanc's discovery in 1791 of a method of making soda ash from salt, sulfuric acid, and limestone, followed by the erection of small soda works at St. Denis, Rouen, and Lille in France. By 1810 the manufacture of sulfuric acid was developed into a continuous process, and in 1823 the large-scale production of soda ash was started in Liverpool. Thus the chemical industry acquired its first great tools—an acid and an alkali—each produced by scientific methods in definite strength and purity, in large quantities, and at reasonable cost.

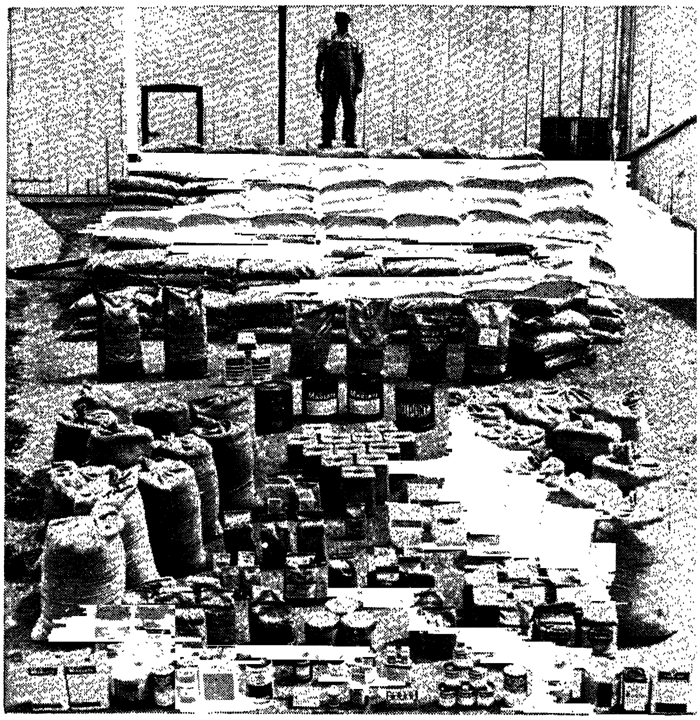
Great Britain, the birthplace of the factory system, was the first important market for industrial chemicals and the first country to produce them in large quantities. For years the Liverpool area, in the midst of a growing market and with nearby supplies of salt, limestone, and coal, remained the leading manufacturing center. Indeed, throughout the first three quarters of the nineteenth century the British alkali industry was the largest chemical industry in the world, such British exports as soda ash, bleaching powder, sal soda, caustic soda, Glauber's salts, and other chemical products becoming famous in many foreign lands.

In Germany important chemical developments began about 1865 with the organization

and early growth of the dyestuffs and potash industries. Following the conclusion of the Franco-Prussian War in 1871, Germany entered an era of peace and industrial expansion that was marked by unrivaled progress in chemical research and manufacturing. This progress had its roots in the German universities, which were the first to emphasize the teaching of physics and chemistry. So widespread was technical education in Germany that even minor executives and salesmen in the chemical industry were formally trained in chemistry. So superior was the quality of technical education offered by German universities that for decades many Americans and other foreign students went to Germany for advanced training.

It was a large supply of trained brains that enabled Germany to make intensive use of such resources as coal, potash, and salt and to find substitutes for so many of the things that she did not have. Among the triumphs of German chemical research were the successful production of dyestuffs from coal tar, the manufacture of solid salts from atmospheric nitrogen, gasoline from coal, and a host of synthetic products, including camphor and rubber. For years prior to World War I the German chemical industry held an advantage in its large and highly trained personnel, a superiority that dwindled as education in the applied sciences became common elsewhere.

Ascendancy of the U. S. chemical industry. While chemical manufacture grew rapidly in the United States after 1880, this country remained dependent upon imports, especially from Germany, for many important chemical products. World War I humbled us by our needs and brought about a tremendous expansion of our chemical industry as the blockade of Germany and the reduction of imports from other European countries forced our market to depend upon domestic producers. Several thousand German patents were expropriated during the war and were made available to U. S. manufacturers, who also received generous tariff protection.



The Du Pont Co. thinks that these are needed each year on a 79-acre farm in Lancaster County, Pa. Acres are: corn 30, wheat 15, hay 25, tobacco 8, potatoes 0.5, vegetables 0.5, cow, and poultry. Chemicals are fertilizer 2, insecticides 7, fungicides 6, weed killer 1, vitamins 2, penicillin and other medicines 4, wood preserver 1, and seed disinfectant 1. *Du Pont Co.*

The United States emerged from World War I with the world's largest chemical industry, supplying about 95% of the needs of the domestic market. Even during the business depression of the 1930's, American chemical production, measured either in tons or dollars, exceeded the combined output of Germany, Great Britain, France, Italy, Japan, and the Soviet Union. At the outbreak of World War II our export trade in chemicals ranked second only to that of Germany, and today it ranks first.[3]

[3] In 1953 United States exports of chemicals and related products amounted to $819 million, chiefly chemical specialties, including explosives; medicinal and pharmaceutical preparations; industrial chemicals; pigments, paints and varnishes; fertilizers and fertilizer materials; coal-tar products; and soap and toilet preparations.

The United States chemical industry has arisen upon a sound foundation. It possesses a large and increasing personnel of chemists, engineers, and technicians trained in American colleges and universities; it has access to a great wealth of raw materials and fuels; it serves a large and growing market capable of consuming thousands of products and byproducts; and it is particularly fortunate in having access to tremendous capital funds.

Each year large sums must be spent upon equipment that is subject to rapid depreciation and obsolescence. Many manufacturers do not expect their equipment to last more than two or three years because of the wear and tear resulting from high temperatures, high pressures, and strong chemical actions and also because of the frequent need of installing new types of equipment. Continuous and large-scale research is costly, and to an increasing degree it is being conducted in the laboratories of big manufacturing corporations and well-endowed universities and research foundations. Since World War I many eminent European scientists have been lured to this country not so much by fabulous salaries as by the splendid laboratory equipment with which they can work. In no other country is so much capital available for research, a powerful factor contributing to the phenomenal rise of our chemical industry. Chemicals invite research. A company lures a battery of researchers; they make discoveries; the company patents a process, owns it, makes the product, makes a million dollars. In a great industrial laboratory products spawn like mushrooms—witness the 200,000 products of stinking coal tar.

The development of a truly great chemical industry in the United States reveals that this country is reaching industrial maturity. Not so many decades ago business enterprise in the youthful United States was confronted by a scarcity of capital and labor. It made only extensive use of raw materials as it skimmed the cream of our natural resources. Today business enterprise has an abundance of capital, labor, and technical skill that are profitably employed in making increasingly intensive use of raw materials through chemical research and manufacture.

Location and control of the U. S. chemical industry. In terms of value added by manufacture, about 55% of chemical production occurs in the northeastern quarter of the United States, east of the Mississippi and north of the Ohio and Potomac rivers. This section is the great market for chemical and allied products. The seven states that lead in production are New Jersey, New York, Illinois, Texas, Pennsylvania, Ohio, and Michigan. The most rapid expansion of the industry, however, is now occurring along the Gulf coast of Texas and Louisiana, a growing industrial region that is well endowed with sulfur and salt, major materials in chemical manufacture.

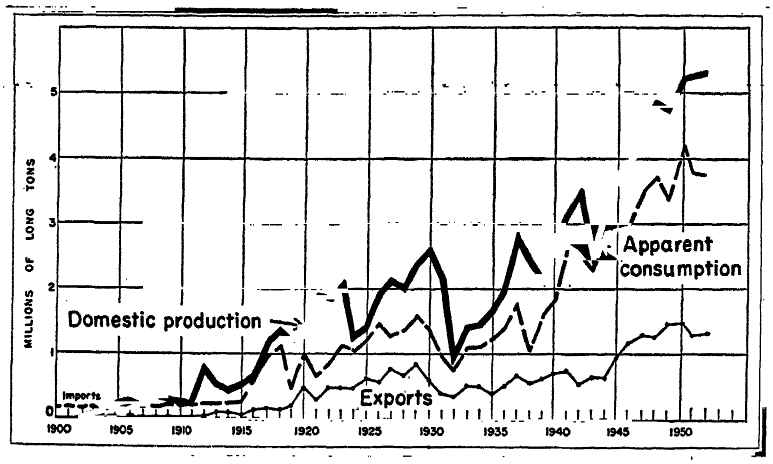
There are more than 10,000 establishments employing nearly 650,000 workers in the American chemical industry. Many companies are engaged in production, but the industry is dominated by three well-integrated firms—Du Pont, Union Carbide, and Allied Chemical. Du Pont is the colossus of chemicals (see Figs. 10 and 477). It has huge central laboratories at Wilmington, Del., nearly 100 plants and over 85,000 employees, assets of about $2 billion, and annual sales of more than $1.3 billion.[4] Other major companies are Dow, American Cyanamid, and Monsanto, each with assets of over $200 million. In contrast, the British and German chemical industries have long been dominated by single firms, the Imperial Chemical Industries, Ltd., and I. G. Farben, respectively.

3. THE RAW MATERIALS

Primary raw materials. Countless products of the land, sea, and air come under the scrutiny of the chemist in his laboratory as he

[4] See Edward L. Allen, *Economics of American Manufacturing*, Henry Holt & Co., New York, 1952, pp. 170–174, and E. I. du Pont de Nemours & Co., Inc., *Du Pont: The Autobiography of an American Enterprise*, Charles Scribner's Sons, New York, 1952.

U. S. crude sulfur—basic chemical. Consider the astonishing newness of our chemical industry. *Adapted from U. S. Bureau of Mines chart*



pursues his research, ever fusing, distilling, and extracting new substances of use to mankind. While a multitude of organic and inorganic materials, gathered from the far ends of the earth, are now used in the chemical industry, only a few are of outstanding importance. In addition to such ubiquities as air and water, the principal primary raw materials are sulfur, salt, limestone, coal, petroleum, potash, phosphate, nitrate, and, more recently, such sources of cellulose as wood and cotton.

These primary materials and others of growing importance are used in the production of secondary raw materials, particularly the great acids and alkalies, which, in turn, are employed in the manufacture of a host of chemicals and other products. Seldom does the first or even the second step in chemical manufacture result in a product that is familiar to a person without technical training or that is of direct use to the average man. Almost inevitably many steps in production must occur between the first use of a primary raw material in the chemical industry and its ultimate consumption in the form of a finished product.

Sulfuric acid. Greatest of all acids and unquestionably the most important manufactured material used by the chemical industry is sulfuric acid. Other acids of great industrial importance are hydrochloric (muriatic), acetic, and nitric. The increase in output of sulfuric acid in the United States from 425,000 tons in 1880 to 3,539,000 tons in 1913, and to about 14,188,000 tons in 1953 strikingly reveals the phenomenal growth of our chemical industry. Between 1939 and 1953 the per-capita consumption of sulfuric acid in this country increased from 73½ to 177 pounds. The production and use of sulfuric acid, like pig iron, is often regarded as an industrial barometer, and some persons even go so far as to say that we can gauge the civilization of a people by the amount of sulfuric acid they use, but, of course, *civilization* has many diverse definitions. We venture to state that it pertains to living and is primarily spiritual, not technological.

The United States leads in sulfuric-acid manufacture with about 45% of the world's total output, other important producers including Japan, the Soviet Union, West Germany, Great Britain, France, and Italy. In this country about 33% of all sulfuric acid is normally consumed in fertilizer factories, and about 23% in the production of chemicals, the remainder being used in petroleum refining, the production of paints and pigments, and the manufacture of rayon and cellophane, iron and steel, coal products, explosives, cotton and woolen textiles, and many miscellaneous products.

Sulfuric acid is made by roasting pyrites or native sulfur, the resulting sulfur dioxide gas being converted into sulfur trioxide that unites with water to form acid. By the use of modern lead-chamber and direct-contact processes, the acid is produced at a cost of less than 1¢ per pound.

Tanks, pipes, and smells—a sulfuric acid plant. Chemical manufacture is mostly unspectacular to the point of invisibility; it just flows along out of sight. ***Chemical Construction Corp.***

Nearly half the world's sulfur is derived from iron and cupreous pyrites, sulfides that are mined chiefly in Japan, Spain, the Soviet Union, Italy, the United States, and Norway. For years the island of Sicily held a virtual monopoly in the production of native sulfur, which is dug from volcanic deposits with much manual labor. It was not until the perfection of the Frasch process in the early years of this century that our large deposits of native sulfur along the Gulf Coast of Louisiana and Texas became available for commercial production.[5] By this unique process water heated to about 300°F. is pumped down into the sulfur beds. Then compressed air is forced down through a second pipe, which forces the molten sulfur (over 99% pure) up through a third pipe to the surface of the earth, where it flows into bins and solidifies. As a result of the development of this process, the United States became the world's largest producer and exporter of sulfur (see Fig. 465).

The treatment of copper and zinc ores yields important quantities of sulfur, which is recovered at the mills as pyrites concentrates or at the smelters as sulfuric acid. Copper-mining companies at Ducktown, Tenn., and Anaconda, Mont., are among the largest producers of sulfuric acid in this country, and they are able to use a noisome (noxious) gas that formerly destroyed the vegetation for miles around. Some by-product sulfur is also recovered from coke-oven gas, petroleum refinery gas, and natural gas.

Soda ash. Sodium carbonate, or soda ash, is the leading alkali and is nearly as important a raw material as sulfuric acid. About 30% of all soda ash in this country is used in glass manufacture and about 25% in making chemicals, the remainder being consumed in the manufacture of caustic soda, the fabrication of nonferrous metals, and the production of pulp and paper, soap, water softeners, and textiles.

Nearly all soda ash is produced by the Solvay process. The chief raw materials are salt (sodium chloride), which provides the sodium, and limestone (calcium carbonate), which supplies the carbon. Coal and coke are used as fuel. Plants that produce soda ash are located in areas where salt and limestone are found close together. Some of the salt is obtained from salt springs and wells, but most of it is obtained by the simple method of pumping water down into rock-salt deposits, dissolving the rock salt underground, and pumping the resulting brine to the surface.

In this country the chief soda works are located at the town of Solvay near Syracuse, N. Y., Detroit, Mich., Baton Rouge and Lake Charles, La., Saltville, Va., and Barberton, Ohio. Small amounts of soda ash are obtained from the brines of Owens and Searles lakes

[5] For the interesting story of the development of the U. S. sulfur industry, see Williams Haynes, *The Stone That Burns*, D. Van Nostrand Co., New York, 1942.

in southern California and also as a by-product from the electrolytic manufacture of caustic soda. With an annual output of 4 to 5 million tons, the United States far surpasses other nations in the production of soda ash.

Caustic soda and chlorine are important alkalies which, like soda ash, are dependent upon salt as a primary raw material. Most caustic soda in this country is used in the rayon, soap, chemical, petroleum, and paper industries, while chlorine is widely used as a bleach for textiles, in the production of dyestuffs and explosives, and in water purification and sewage disposal.

Most of our cities could not exist as at present without the purification of river water—chlorine, the hero.

4. THE MANUFACTURE OF EXPLOSIVES

Uses. Explosives have long been the most spectacular of the chemists' products. Long used for destruction only, they have only recently entered industry and are performing rapidly increasing services, since dynamite has become cheap. Without dynamite and gunpowder the prosecution of the mining and quarrying industries, and the building of our railways, tunnels, subways, and canals would be impossible. The production of industrial explosives in the United States now amounts to more than 760,000 tons a year, or about 9 pounds per capita.

Plant location. The danger and consequent cost of transport is the dominating factor that scatters the centers of manufacture, as high freights scatter cement plants. The assembling of the raw materials is much easier than the handling of the finished explosives, but it is a distinct advantage to have the plants on tidewater. The Delaware River has long been the greatest location for the manufacture of explosives, with the center at Wilmington, Delaware. The Newark Bay area in New Jersey and the Gulf Coast of Texas are also the sites of important plants engaged in the production of explosives. The great danger of explosives causes the plants to be located at a considerable distance from city limits, often in or near coastal marshes, swamps, pine barrens, and other wastelands.

Raw materials. The god of war has developed a Gargantuan appetite for many materials as well as for many men, and it now costs several thousand dollars to kill a single soldier in battle as compared with only 24¢ in the time of Julius Caesar.[6] As late as our Civil War the ingredients of warfare were simple, namely, the charcoal, sulfur, and saltpeter that were used in making cheap black gunpowder.

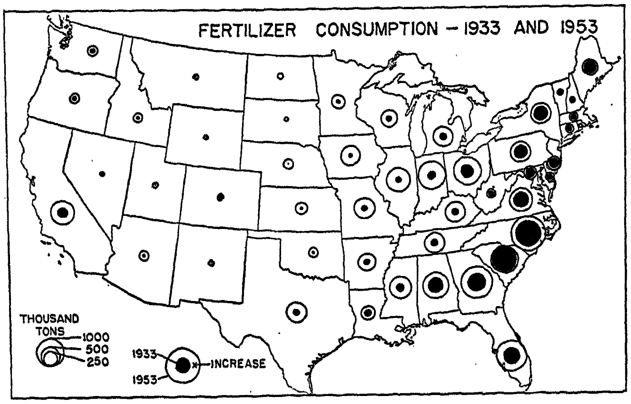
Modern warfare makes extensive use of high explosives that are obtained from combinations of many materials. Thus cotton and wood yield cellulose, vital in the production of nitrocellulose and smokeless powder. Various fats and oils are employed in the manufacture of nitroglycerine and dynamite. Acetone, derived from the fermentation of corn, and common grain alcohol are needed to make smokeless powder. Petroleum refineries and coke ovens yield toluene, basic material in trinitrotoluene and amatol, and benzine for the production of tetryl, trinitrotoluene, and picric acid. Nitrogen is derived from the air, the coke oven, and natural deposits of sodium nitrate. It is made into nitric acid, which is generally mixed with sulfuric acid and is indispensable to the manufacture of almost every high explosive.

The mighty little atom has come to be the most powerful explosive of them all. The production and use of this explosive is strictly controlled by a few national governments.

5. THE FERTILIZER INDUSTRY

Importance of the fertilizer industry. The fertility of soil—the most fundamental of all resources—depends upon the presence of phosphorus, potassium, nitrogen, calcium, magnesium, sulfur, and other elements in accessible forms and in proper amounts. Phosphorus, potassium, and nitrogen are the principal elements in commercial fertilizer, the

[6] Harry N. Holmes, *Strategic Materials and National Strength,* The Macmillan Co., New York, 1942, p. 47.



One reason crops increased without area increase. Million tons 1933, 5; 1953, 20.2. Area of circles deceptive. Indiana had 100 fold increase. ***Data from National Fertilizer Association***

manufacture of which has become an important branch of the modern chemical industry.

Farmers in the United States now spend nearly $1 billion a year on fertilizer. Between 1939 and 1953 the consumption of commercial fertilizer on our farms increased from 7½ to 22 million tons. To meet the growing demand, more than 700 fertilizer plants, employing over 30,000 workers, are engaged in production.

The animal, vegetable, and mineral kingdoms contribute many materials suitable for use as fertilizer. The fertilizer manufacturer, however, relies chiefly upon three important mineral raw materials—phosphate, potash, and nitrate—and, more recently, upon nitrogen obtained from the air.

Phosphate rock. The fossil remains of animal life, in the form of phosphate rock, are by far the largest sources of phosphorus today. The great bulk of the world's phosphate rock reserves are concentrated in French North Africa, the United States, and the Soviet Union. A recent survey warns:

> Unless important reserves are found in Asia or Australia, in the future either the United States or France will probably export a considerable volume to such countries as China and India where far less fertilizer is being used than is required for efficient agricultural production. Phosphate has been called "the bottleneck of the world's hunger."[7]

It is estimated that U. S. phosphate-rock reserves mineable under present economic conditions will last for more than 1300 years at the present rate of consumption.[8] Of some 4 billion tons of mineable or economic reserves, approximately 2½ billions are located in Florida; about 1½ billions are in Montana, Idaho, Utah, and Wyoming; and about 0.1 billion is in Tennessee. Our resources of fairly high-grade phosphate, not mineable under present conditions, amount to at least 8 billion tons, fully 80% being located in the western fields.

Within the last 25 years two technological advancements have made possible the recovery of low-grade phosphate that formerly was considered uneconomic. One is the use of the froth-flotation process, doubling the recovery of phosphate from the pebble-phosphate deposits of Florida. The other is the production of phosphorus by the electric furnace, permitting the use of low-grade siliceous phosphates.

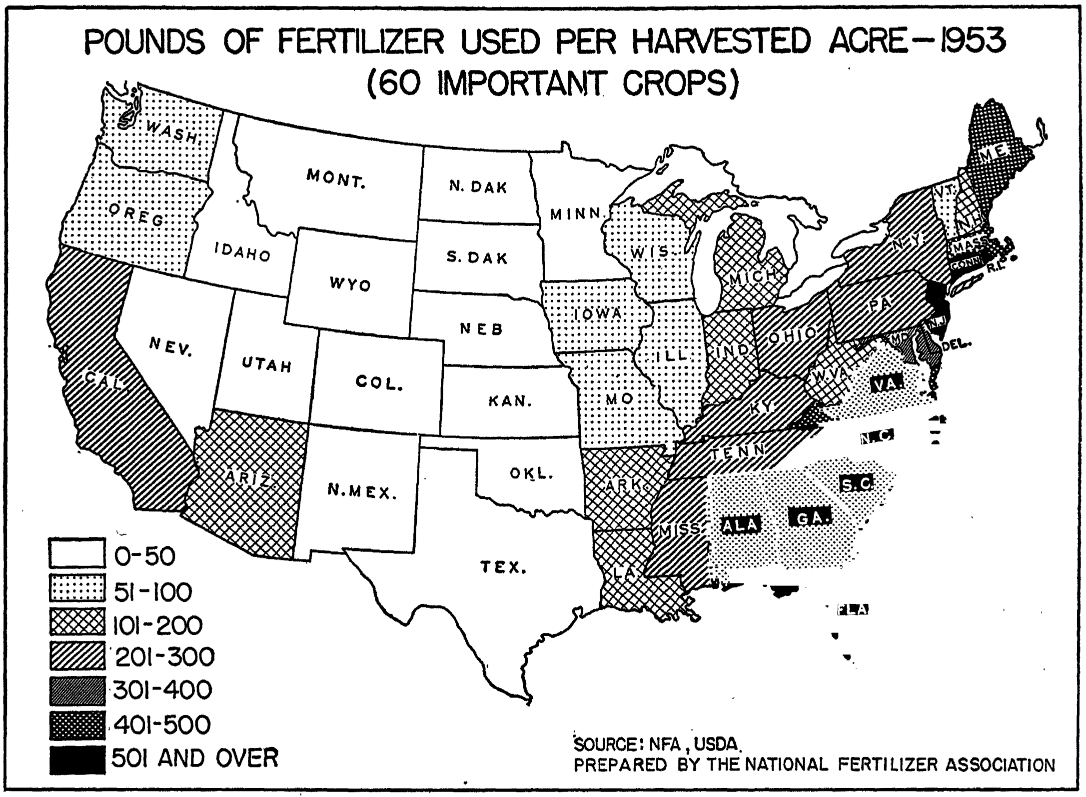
More than 11 million tons of phosphate rock are mined in the United States every year, or about half the world's total output. In terms of phosphorus pentoxide content, more than 80% is produced in Florida, about 12% in Tennessee, and the remainder in the West. In contrast with the eastern deposits, which lie near the market and are easily worked by open-pit or hydraulic methods, the huge western deposits are remote from major markets and must be worked by costly shaft-mining methods.

The United States exports nearly 2 million tons of phosphate rock a year, chiefly to Canada, Italy, Japan, the Netherlands, West Germany, and Great Britain. Tampa, Florida, is the leading port of shipment.

About 30% of the world's phosphate rock is mined in French North Africa—Morocco, Tunisia, and Algeria—which has mineable or economic reserves amounting to about 23 bil-

[7] The President's Materials Policy Commission, *Resources for Freedom*, Washington, Vol. 2, 1952, p. 156.

[8] *Ibid.*



Heavy rainfall, more leaching (p. 48), more fertilizer (see Fig. 55). Also look for the states that grow big crops of tobacco, citrus fruit, and vegetables. Dry West is still fertile.

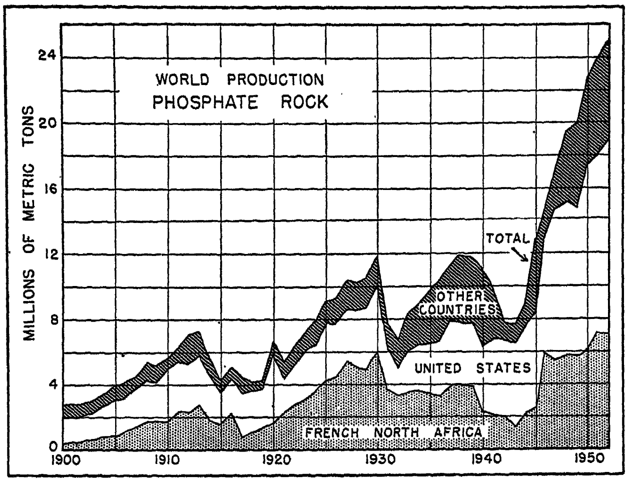
lion tons. French North Africa normally supplies 50% to 80% of the requirements of Europe. North African phosphate is of greater purity than that of Florida and lies nearer to the European market. It occurs near the surface and is easily worked by open-pit or adit methods and with cheap Arab labor. It must be exported if it is to be sold at all, since the domestic market is negligible. Kourigha, Morocco, Gafsa, Tunisia, and Tebessa, Algeria, are the leading mining centers.

The Soviet Union ranks third in phosphate rock production, with an annual output of about 2½ million tons. Mineable or economic reserves amount to at least 5½ billion tons. Mining occurs at Khibini on the Kola Peninsula, between the Volga and Dnieper rivers, and at Aktyubinsk in northern Kazakhstan. The entire output is destined for domestic consumption.

Nauru Island in the South Pacific mines about 1 million tons of phosphate rock each year and exports it to Australia and Japan. Other producers of lesser importance are Egypt, Ocean Island, and Makatea Island.

Treatment of phosphate rock. While phosphate rock is sometimes ground and applied directly to the soil, this method of fertilization is not very effective. The phosphorus in phosphate rock usually enters fertilizer mixtures in the form of phosphoric acid, which is made by treating the rock with sulfuric acid, the resulting product being known as acid phosphate or superphosphate. The great bulk of all phosphorus today is used in fertilizer, but in various forms phosphorus also enters into the production of matches, bullets, baking powder, boiler compounds, dyestuffs, pharmaceuticals, jellies, soft drinks, and stock and poultry feed.

Other sources of phosphorus. For some years increasing amounts of phosphorus have been derived from the basic Bessemer and basic open-hearth processes of iron and steel



U. S. riches. Our phosphate reserves. A vital base for well-fed 1000 years. ***U. S. Bureau of Mines***

manufacture. The limestone linings of the converters and furnaces draw the phosphorus from the molten iron and steel, and they are later ground up and sold under the name of basic slag, or Thomas meal. Nearly all the world's basic slag is produced in Germany, France, Belgium, and Luxembourg, where phosphoric ores are of outstanding importance in steel making and where long-used farm lands require much fertilizer; yet each of these countries depends largely upon imports of phosphate rock.

Meat-packing plants find it profitable to manufacture fertilizer from bones, blood, and other waste that is rich in phosphorus and nitrogen. Likewise fish canneries utilize fish scrap. During the nineteenth century bone hunters roamed our Great Plains and the Argentine pampa, and large shipments of bones were made to the fertilizer plants of eastern United States and western Europe.

Chinese and Japanese farmers were the real pioneers in the fertilizer business. Centuries ago they began to apply animal manure to growing crops, and also human excrement, known as "night soil" because it is collected at night. This practice has been continued to the present day—and proves that stench does not kill.

Potash salts. The great bulk of the world's potassium is derived from a few large deposits of potash salts laid down in geologic times. The reserves in deposits now being mined contain about 5 billion tons of potassium oxide, or enough to last for more than 1000 years at the present rate of use. By far the largest reserves are in East Germany, West Germany, and the Soviet Union. Sizable deposits are located in Israel-Transjordan, France, Spain, and the United States. Our reserves are believed to be adequate for more than 100 years at the present rate of use.[9]

For many years the United States was completely dependent upon imported potash. Americans could buy potash only from a powerful cartel, dominated by German firms. All major producers belonged to the cartel, which had complete control over output, exports, and prices. Fortunately for American consumers, the coordinated effort of our federal government and private enterprise finally resulted in the discovery and successful exploitation of valuable potash deposits in an area of about 40,000 square miles east of Carlsbad, N. Mex., that extends into western Texas. Commercial production got under way in 1931, and by 1938 this country produced about 12% of the world's potash, the huge German deposits at Stassfurt and the French deposits in Alsace being the largest producers. At the time of our entry into World War II about 82% of our potash supply was mined in the Carlsbad area, the remainder being derived chiefly from the brines of lakes in the West. The chief handicap of the Carlsbad deposits is the 400-mile rail haul to ports on the Gulf of Mexico.

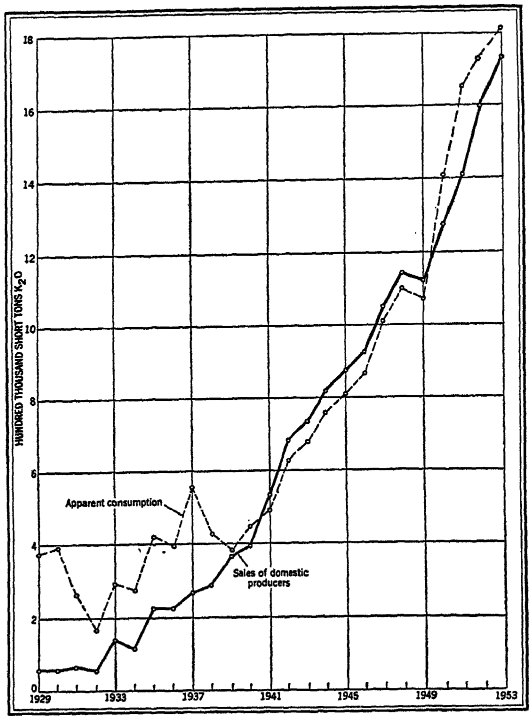
The United States is about self-sufficient in potash, and its exports and imports are small. In terms of potassium oxide content, approxi-

[9] In terms of potassium oxide content, the reserves of East Germany are estimated at about 14,000 million tons; West Germany, at 2 to 20,000 millions; the Soviet Union, 700 to 18,400 millions; Israel-Transjordan (the Dead Sea), 1200 to 1400 millions; France, 300 to 400 millions; Spain, 270 to 500 millions; and the United States, about 250 millions. *Ibid.*, pp. 157–158. Newly discovered potash deposits in Saskatchewan, Canada, and eastern England have not been evaluated.

mately one fourth of the world's potash is produced in the United States, about one fourth in West Germany, and nearly one fourth in France, the remainder being mined chiefly in East Germany, the Soviet Union, and Spain.

Fully 90% of all potash is consumed in the production of fertilizer. The remainder is used in the manufacture of soap, glass, munitions, high-octane gasoline, drugs, photographic materials, dyes, and other products.

Other sources of potassium. Playa deposits in desert areas and the brines of some salt lakes are rich in potassium. The brines of Searles Lake in southern California and the Dead Sea of Israel and Transjordan are evaporated, and potash crystals remain. Thus deadly water of the Dead Sea becomes a fabulous mine. Wood ashes have been used for fertilizer, and leached to get lye (potash) for colonial and rural soapmaking. Alunite, feldspar, greensand, and shale are potential sources of potassium. During World War I, when the United States was desperate for potash, a seaweed known as kelp was harvested along the coast of California, burned, and its ashes used for fertilizer.



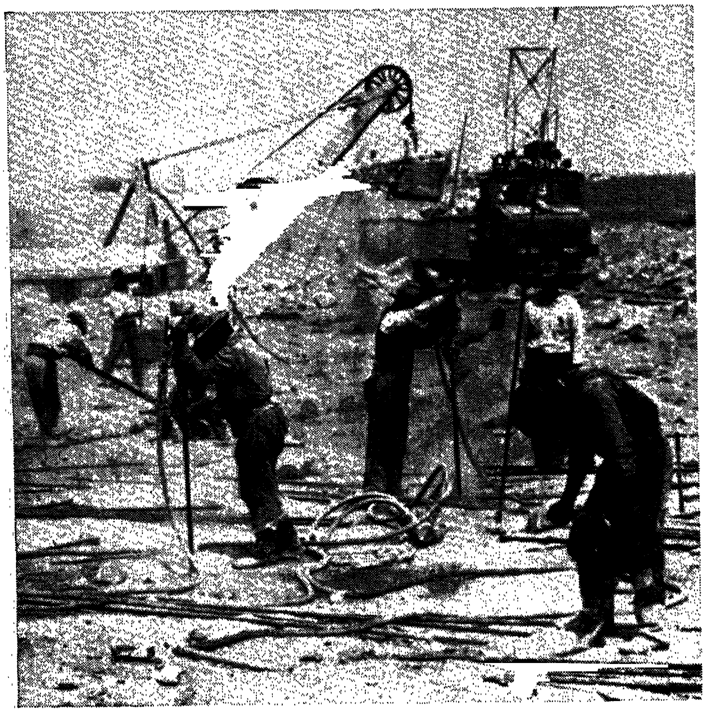
Potash—a basic chemical and fertilizer. Long a monopoly of Europe, ours goes up like a rocket. *U. S. Bureau of Mines*

Chemical or inorganic nitrogen. The third great fertilizing material is nitrogen, which in various forms provides vital foods for plants and sustenance for human life. Paradoxically, in the form of nitric acid as an ingredient of munitions and explosives, it is also one of the most powerful agents in human destruction. In times of peace more than 85% of all inorganic nitrogen is consumed as fertilizer, the remainder being used for such purposes as refrigeration, water-supply treatment, and the manufacture of nitric, sulfuric, and other acids, various alkalies, rayon, nylon, rubber, plastics, and other products.

There are three main types of inorganic nitrogen in use today: (1) atmospheric nitrogen, or synthetic nitrate, (2) by-product nitrogen, or ammonium sulfate derived from coal, and (3) natural sodium nitrate, or *caliche,* which is mined in northern Chile. More than 75% of the world's inorganic nitrogen is now derived from the air, less than 20% is a by-product of coal, and less than 5% comes from the mines of Chile, which have had an interesting history.

The Chilean nitrate story. Natural sodium nitrate in commercial quantities is a monopoly of the Desert of Atacama in northern Chile. Between 1880 and 1900 exports increased from ¼ million to 1½ million tons, reaching a peak of nearly 3 million tons a year in 1916–18 and an all-time peak of more than 3 millions in 1929. From 1880 until 1930 the Chilean government levied a tax of $12 a ton on all nitrate exports, and it reaped a golden harvest that averaged $25 million a year. Competition from by-product and atmospheric nitrogen caused the collapse of the Chilean nitrate industry, exports dwindling to ¼ million tons in 1932. Since World War II nitrate exports have averaged about 2 million tons a year.

The Chilean nitrate deposits are scattered irregularly throughout a zone about 450 miles



Pneumatic drills, electric shovels, and Chilean desert dust. Crude nitrate, water 100 miles away. ***Chilean Nitrate Educational Bureau, Inc.***

long that extends from 19° to 26°S. Lat. and lies chiefly along the eastern side of the coastal range. The *caliche,* or nitrate-bearing stratum, varies in thickness from a few inches to 10 feet or more, and may be found at the surface of the earth or 25 feet below; it varies in nitrogen content from a mere trace to as much as 60%. So firmly does the nitrate cement the rock material with which it is associated that much blasting is usually necessary. The material is scooped up by giant electric shovels and is carried by narrow-gauge railroads to the *oficina,* or nitrate-treatment plant, where it is crushed by huge machines that handle as much as 16,000 tons a day. The crushed material is dumped into great vats and is dissolved by boiling water, the solution being sent to cooling vats where the nitrate is precipitated and the water is drawn off to be used again. The nitrate is piled on cement floors, where it dries rapidly in the desert air, and is later shipped in 200-pound bags to Antofagasta, Iquique, and other coastal towns for export.

The chemist takes a hand. At the very time when large-scale production of Chilean nitrate was getting under way, competition began to appear. About 1880, Germany, France, and Belgium began to replace their beehive coke ovens with by-product ovens which collected the gases that formerly went to waste. One of these gases is ammonia, which in pure form is 82% nitrogen. When ammonia is passed through sulfuric acid, it is converted into ammonium sulfate, an excellent fertilizer material. Since ammonium sulfate is only one among a great many products derived from the coke oven, it can be sold at a very low price, but the output, of course, is limited by the extent of coke-oven activity. Ammonium sulfate is also obtained as a by-product of the manufacture of artificial gas from coal. More than 80% of all by-product nitrogen is made in the United States, the Soviet Union, West Germany, and Great Britain, great industrial nations that are important producers of coke and artificial gas.

The inexhaustible atmosphere is the greatest of all nitrogen sources today. About 75½% of each cubic foot of air by weight is pure nitrogen gas, approximately 22 million tons of it resting upon every square mile of the earth's surface. Nitrogen is an elusive and recalcitrant element, and it was not until the early 1900's that man perfected three nitrogen-fixation processes that made possible the recovery of nitrogen from air.

The arc and cyanamide processes require large amounts of very cheap electricity, and the arc process is now obsolete.[10] The cyanamide process was used extensively before

[10] The arc process was developed in Norway about 1900 and was used there for 24 years. In this process heated air is passed through a huge electric arc, the oxygen and nitrogen of the air combining to form oxides, which are subsequently absorbed in water to make nitric acid. The cyanamide process was developed in Germany about 1900 and involves the use of coke and limestone in electric furnaces to make calcium carbide, which is treated with nitrogen gas under slight pressure at a temperature of 2120°F. to form calcium cyanamide that can be treated with water and steam under pressure to make ammonia.

World War I but is now rapidly declining in importance. In contrast, the Haber-Bosch process has much smaller power requirements, and its energy supply does not have to be electrical. This process, or various modifications of it, is by far the leading source of inorganic nitrogen today.

The Haber-Bosch process of producing synthetic ammonia was perfected in Germany in 1913 in time to help supply that nation with ample nitric acid during the ensuing four years of war. The success of this process was largely the result of newly developed chemical knowledge of catalysts.[11] In the Haber-Bosch process pure hydrogen from water gas and pure nitrogen from producer gas are combined under great pressure at a temperature of 1022°F. in the presence of small amounts of a catalyst, such as iron oxide. The nitrogen comes from the air, for producer gas is made cheaply by passing a mixture of air and steam through an incandescent bed of coke, anthracite, low-volatile noncoking coal, or even lignite. The hydrogen is usually derived from water gas made by passing steam through incandescent coke or other fuel, but it is being obtained increasingly from coke-oven gas, from the electrolysis of water and brines, and more recently from natural gas.

As a result of increasing production of nitrogen from the air and from coal, the leading industrial countries of northwestern Europe are self-sufficient in nitrogen and have a surplus of nitrogenous products for export. In the United States atmospheric nitrogen now accounts for about 70% of our supply of inorganic nitrogen; natural sodium nitrate imported from Chile, about 20%; and by-product nitrogen, only 10%.

Other sources of nitrogen. Animal manure, human excrement, slaughterhouse waste, fish scrap, cottonseed cake, soybean cake, tobacco stems, and composts are fertilizer materials containing nitrogen.

As fertilizer the ancient Incas of Peru used guano, the bird excrement that accumulates on the arid Chincha Islands. Guano lacks potassium, but it contains phosphorus and is 33 times richer in nitrogen than barnyard manure. The Incas regarded it so highly that they imposed a death penalty on anyone killing a guanay bird. Guano was Peru's leading export a century ago, but the supply has been so depleted that its export is now prohibited. Guano is now mixed with other fertilizers prior to use on Peruvian farmlands.

The ancient Chinese were pioneers in the use of soybeans and other leguminous crops, which through nature's ingenuity are able to transfer nitrogen directly from the air into a plant (see Fig. 474). The roots of most legumes produce nodules which harbor bacteria that absorb and distribute about 60 pounds of atmospheric nitrogen per acre per year.

From the days of Jamestown and Plymouth Rock until the twentieth century Americans were agricultural savages who slaughtered their soils. Only in recent times have U. S. farmers made extensive use of clover, soybeans, velvet beans, and other legumes for the purpose of restoring soil fertility. And soil is the stuff from which the future must eat!

The location of fertilizer industries. In this country fertilizer plants are to be found in or near almost every port from Maine to Texas. A tidewater location facilitates the assembly of the bulky fertilizer materials—Chilean nitrate, potash from our Gulf ports or from Germany, and phosphate from Tampa, Fla. Nearly half of the nation's fertilizer is manufactured in Georgia, North Carolina, Virginia, Florida, and Maryland, fertilizer plants in this belt of South Atlantic states being well located to serve the cotton, tobacco, and fruit lands of the South and the intensively cultivated truck farms that are scattered along the coast from Florida to Long Island, N. Y.

---

[11] A catalyst is a substance that by its mere presence causes the union of two other substances that might otherwise remain separate. Thus finely divided nickel is used in the hydrogenation of petroleum. Like the minister at a wedding ceremony, the catalyst is momentarily involved in performing an important service.

Manna. About three fourths of our atmosphere is composed of nitrogen. It is the chief material for protein—the muscle maker. Fortunately for us, whole tribes of plants become the hosts to colonies of bacteria that form nodules and live upon the roots of the plants, gather nitrogen from the air, feed it to the plants, and leave some in the ground for succeeding plants.

(Left) Life-size nodule of a velvet bean. *(Top right)* Three soybeans, the age-old prop of the Orient, the new wonder of the Corn Belt. *(Bottom right)* Alfalfa—the milk-producing hay—the valued winter feed of the irrigated meadow in the land of the Great Open Spaces. *U. S. Bureau of Reclamation*

About one half of all commercial fertilizer is consumed in the southeastern quarter of this country, a section where the use of chemical fertilizer is imperative, for here excessive leaching has been caused by heavy rainfall that occurs in both winter and summer, by the fact that winters are mild and the earth is almost never frozen solid, by the prevalence of easily leached, sandy soils, and by the long-continued practice of one-crop farming in large areas. The most significant thing about United States fertilizer is the recent great increase in its use in the Corn Belt. Corn plants must eat. Hybrid corn that yields a lot must eat a lot. Some Corn Belt states have increased their use of commercial fertilizers tenfold in 10 years. Three cheers for phosphorus, potassium, nitrogen, and legumes! We are following in Europe's footsteps (see Figs. 468 and 469).

The manufacture of fertilizer is a highly developed industry in western Europe, one of the world's big markets for fertilizer materials. The long-used and generally sandy soils of western Europe have been made highly productive by the use of commercial fertilizer, crop rotation, and other scientific practices. The great German statesman Otto von Bismarck once said that Prussia was built out of a sand box.

6. SOAP MAKING AND ITS MATERIALS

The soap revolution. For many years soap has been made by the action of soda ash or potash upon animal and vegetable fats and oils. Year after year a host of materials is as-

sembled for use in soap factories. Among them are the oil of babassu nuts, castor beans, coconuts, corn, cottonseed, olives, palm kernels, peanuts or groundnuts, poppyseed, rapeseed, sesame, and soybeans, train oil from the blubber of whales, the oil of menhaden and other inedible fish, the fat and grease of cattle and hogs and sheep that reach life's end in meatpacking plants, and even the grease in sheep's wool that is being prepared for the loom. The international commerce in soap-making materials is far greater than the commerce in soap.

Along comes the chemist, who has become an old hand at starting revolutions.[12] As the result of his research, synthetic materials now account for 37% of all materials used in American soap factories. The production of synthetic detergents is rapidly increasing, and kitchen and laundry soaps made from animal and vegetable fats and oils are on the wane. In five years, 1948–52 inclusive, the production of detergents in this country increased from 0.4 to 1.8 billion pounds, while the output of soap dropped from 3.7 to 2.3 billion pounds. In 1953, for the first time, more detergents were sold than soap. Soapsuds are rapidly giving way to synthetic suds, which, in turn, are being displaced by sudsless detergents. The chemist has discovered that lazy suds on the surface of the water do very little work.

The value of soap and related products shipped from American soap factories amounts to more than $1 billion a year, or over $7 per capita. Americans are perhaps the most freshly scrubbed people in the world—except the Japanese.

Tallow, olive, cottonseed, and peanut oils. Tallow, the standard fat of northern countries, has for a century been the product of the most remote sheep- and cattle-pasturing districts, and it comes today from the sheep ranches of the Falkland Islands, Argentina, South Africa, Australia, New Zealand, and from Asiatic countries, as well as from slaughterhouses in our big cities. Olive oil is the standard soap fat of Mediterranean countries, and Marseilles is one of the great world centers for the importation and the processing of vegetable oils and fats. Marseilles is located near the French olive district; it is also a natural gateway to northern Europe for the olive oil shipped in small vessels from the numerous parts of Spain, Italy, and North Africa.

In recent decades new industrial movements have given other oils as rivals of, and substitutes for, the oil of olives. Marseilles, the oil center, has attracted much of this trade. One material is cottonseed oil, its purer grades being largely used for food in South Europe as a substitute for olive oil, while the lower grades serve as a soap material in the Marseilles markets and factories. Peanut oil is another rival of olive oil for both food and soap, and is imported into France from a dozen places in Africa, Asia, and the Americas.

Coconut oil and copra. The oil of the coconut, rich in lauric acid, is needed to provide the easy lather and copious suds that are so highly prized by the modern consumer. Coconut oil is also widely used in the manufacture of margarine, lard substitutes, and glycerine.

The coconut, one of the most promising of all oil producers, thrives upon the tropic seashores almost everywhere. However, most of the copra (coconut meat) and coconut oil that enter world commerce come from the Philippines, Indonesia, the South Sea Islands, Ceylon, and British Malaya.

Although large plantations owned by the Americans in the Philippines and by the British in Ceylon and Malaya are of growing importance, the great bulk of the commercial crop is produced by natives on their little plots of land. Copra is generally exported in full cargo lots in tramp ships, while coconut oil is now shipped in the holds of tankers equipped with steam coils to keep the temperature above 74°F. so that the oil will not solidify.

Palm oil and palm kernels. Palm oil is another tropic vegetable oil that is of growing

[12] Manufacturing Chemists' Association, Inc., *op. cit.*, p. 5, and "Modern Living," *Time*, February 9, 1953, p. 90.

importance to soap and margarine manufacturers, especially in Europe. In the rain forest of the Congo and Niger basins and along the Gulf of Guinea the breech-clothed African climbs the 30-foot palm tree and cuts off its head of fruit, as big as a basket. The many small fruits are thrown into a kettle of water, boiled, and then tramped by bare feet to crush out the oil, which is skimmed from the surface of the water. This is refined by further boiling, and used throughout much of Africa as a choice morsel of food, a substitute for the olive oil of Europe and the butter of America. Almost never will a native chop down a palm tree when he clears a bit of the forest for farming, for the oil of the palm is often his only cash crop. From the seaports of western Africa the oil is usually transported in barrels by tramp ships to markets overseas.

On the other hand, palm oil production in Indonesia and British Malaya is conducted almost entirely on large plantations, the oil being exported in tankers. In most years Nigeria, the Belgian Congo, Indonesia, British Malaya, and French West Africa produce over 90% of all palm oil that enters the channels of trade.

Palm kernels, as well as the fruit of the palm tree, are rich in oil and are collected and shipped in bags chiefly to the crushing mills of Europe, over 90% of the world's palm kernel export coming from Nigeria, the Belgian Congo, Sierra Leone, and French West Africa.

Here is a suggestive episode. Much of the small export of palm kernels from Liberia is carried for a week or two on the female African head and finally sold to pay for needles and thread and a few other things considered necessary in the native psychology. One year the price of kernels suddenly doubled and the export as suddenly went down 50%. Effective demand for imported goods could be supplied by half as many kernels. Why do more work? How many of us would work next year if each of us inherited a million dollars tomorrow?

The soap industry. In the United States soap manufacture is dominated by a few large companies—Procter & Gamble, Lever Brothers, and Colgate-Palmolive-Peet. Soap factories are quite generally distributed throughout the industrial areas of the country, with Cincinnati, Chicago, Milwaukee, and Philadelphia as major centers of production. In Europe the great ports of Liverpool, Marseilles, Antwerp, and Rotterdam are old and important soap-making centers.

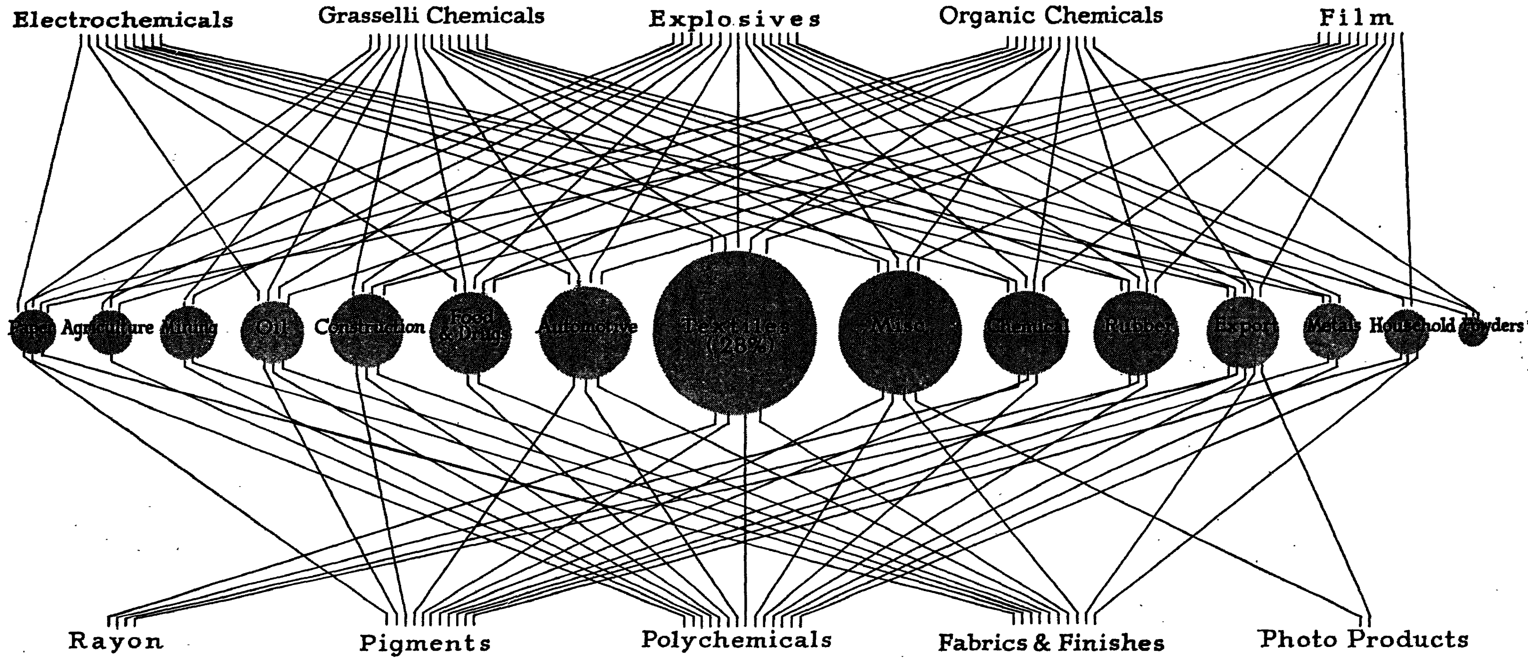
Soap can be made from virtually any animal fat or oil, and soap is made in every country in the world. Only a generation or two ago the American housewife saved all cooking grease and made kitchen soap. In many parts of the world soap making is a household industry. Soap is a luxury for the poorer people in many lands, and millions remain among the great unwashed.

7. COAL-TAR DYES

Natural and synthetic dyestuffs. One of the chemical manufactures most typical in its scientific nature, its importance, and its relation to other industries is that of dyestuffs. For thousands of years man dyed his clothing with natural colors made from herbs, barks, and other vegetable and animal products. Their quality has not been excelled. The famous Tyrian purple of the ancient Mediterranean peoples was made from the pulverized shells of certain mollusks. Scarlet was later obtained by the use of cochineal, a dyestuff prepared from the dried bodies of insects native to Mexico and Central America. The rough homespun of the American backwoodsman was dyed a rich brown by the use of butternut hulls.

Artificial dyestuffs derived from that well-nigh infinite chemical mine, coal tar, are of relatively modern discovery. In 1856 W. H. Perkin, an English chemist, while experimenting with aniline (a substance derived from coal tar), produced a purplish or mauve dye. Still other experiments resulted in the chemists' developing a whole range of colors, which became popularly known as aniline dyes. Over 1600 distinct color dyestuffs have been developed, and the total number of coal-tar dyes

DU PONT'S INDUSTRIAL WEB



The chemical industry reaches throughout the industrial world with a universality that resembles the law of gravitation. *TIME diagram by R. M. Chapin, Jr. Copyright Time Inc. 1951*

recognized by chemists is apparently unlimited. Chemistry has thus turned a former waste product from the coke oven into a source of the rainbow hues used by man in coloring his clothing and articles of daily use.

The German dye industry. While Great Britain led the world in the early manufacture of coal-tar dyes, after 1871 production shifted rapidly to Germany and was dominated by that country until World War I, largely because of the outstanding progress achieved by German universities in chemical education and research.[13] The first aniline colors were so inferior to the natural dyes that people became suspicious of anything named aniline, a prejudice which was hard to overcome. By years of careful laboratory work the German scientists finally produced a range of artificial colors so excellent that they displaced the natural dye products, and so low in price that the rest of the world found it cheaper to buy from Germany than to develop a color industry. Synthetic indigo was so successful that the export of natural indigo from India decreased from 21,000,000 pounds in 1896 to 5700 pounds in 1938. Only the cheap labor of India makes any export possible. Likewise competition from synthetic dyestuffs brought about a great decline in the export of dyewoods from the moist eastern lowlands of Central America.

Prior to 1914 Germany controlled the dye industry, with over three fourths of the world production. In addition she furnished over one half the primary and intermediate products used by other countries in their limited dye industries. The total export of coal-tar dye products from Germany declined from about $50 million in 1913 to $44 million in 1938.

Rise of the dye industry in the United States. Soon after the beginning of World War I, a number of the largest textile-manufacturing countries, including Great Britain, the United States, France, and Italy, found themselves cut off from their regular source of dye supply. The development of colors at home became an urgent necessity. The manufacture of coal-tar chemicals had never been seriously attempted in the United States, and the first colors produced by the hastily organized industry were nearly as unsatisfactory as the crude dyes of the early aniline experimenters. However, the manufacturers called in the best chemists, spent money freely on technical research, and finally were able to develop home dyes that compared favorably with the imported ones. Stimulated by the war demand, chemical and dye plants were erected almost overnight, and they succeeded not only in supplying the home demand but in capturing a large part of the former German export trade.

Between 1925 and 1952 the production of synthetic dyes in the United States increased from 86 to 145 million pounds. About 50 plants are engaged in production, with an annual output valued at over $170 million. Only 3% of our dyes are now imported, as compared with 96% in 1913.

This dye story is one of a multitude that might be told to show how unprofitable it has been for Germany to start the two world wars. She began the first in a state of great and growing prosperity. She ended the second in utter collapse.

8. PLASTICS

The nature of plastics. World War II, with its many substitutions of plentiful materials for those that were scarce, greatly stimulated the manufacture of a group of chemical products known as plastics. These plastic materials

[13] Whereas "academic" and "theoretical" were sarcastic epithets among banking and industrial circles in Great Britain for years prior to 1900, German scientists were encouraged in their research work by both government and industry. After 1871 the superb German chemico-technical schools were almost entirely supported by the state. The successful production of synthetic indigo in 1897 was the culmination of 17 years of patient research and involved an expenditure of $5 million. In 1900 about 84% of the technical and sales staffs of all German dye companies possessed formal training in chemistry. See Theodore J. Kreps, "Modern Dyestuffs," *Encyclopaedia of the Social Sciences,* The Macmillan Co., New York, Vol. 5, 1931, p. 302.

used by John Wesley Hyatt in 1869 in the manufacture of celluloid, the pioneer of all plastic products.

A recent development in the plastics industry is the use of lignin, the soluble substance that cements the cellulose fibers of wood. Lignin is obtained from wood chips and from the sulfite liquor that formerly was wasted in paper manufacturing, and it is also to be found in corncobs, oat hulls, and sawdust.

Another group of plastic materials of growing importance are the protein compounds derived from soybeans, dried blood, milk, and other sources.

Probably the most important of all plastic materials at present are the phenol compounds, or synthetic resins made from carbolic acid and formaldehyde, which were first used about 1910 in the manufacture of bakelite. Other competing resins are the vinyls derived from lime and coal and urea formaldehyde obtained from ammonia and carbon dioxide. In making plastic compounds, these basic materials are generally used in conjunction with other ingredients known as plasticizers, including fillers, lubricants, pigments, and dyes.

Methods of fabrication. Much of the success of the modern plastics industry is undoubtedly due to the great progress achieved in the methods of fabrication, such as the art of molding. To design adequate molds and dies for specific products requires great skill and experience, especially in the production of curved and odd shapes. Indeed, many compounds are known by chemists to have interesting possibilities of use, but they remain of no commercial value because no practical or economical method has been devised to solve the physical and chemical problems of processing and fabrication.

The oldest and most widely used method of shaping plastic compounds is compression molding. In this process preformed material is placed in heated steel molds that are closed, heated, and subjected to pressures of 1000 to 8000 pounds per square inch, the material flowing into the mold cavities where it cures in solid and permanent form. If injection molding is employed, the exact amount of plastic material is preheated and then forced in viscous form under pressure through a nozzle into a die of one or more cavities, the die being closed for a few seconds under pressure of 10,000 to 30,000 pounds per square inch, after which the finished product is ejected, and the production cycle is repeated. Much of the manual labor formerly used has been displaced by automatic machinery. In contrast with most fabrication of wood and metals, there is very little wastage of raw materials in the molding of finished plastic products.

Some plastic products are fabricated by extrusion, the material in the form of powder, grains, or continuous ribbons being fed into a heated cylinder, whence it is forced by screw or hydraulic pressure through dies that form rods, sheets, tubes, or cross-sectional shapes. A relatively new process is lamination, a solution of plastic material being used to saturate layers of fabric, fiber, paper, or wood that are built up in great piles. These layers are converted by heat and pressure into hard and homogeneous sheets, rods, tubes, or other shapes that can be drilled, punched, sawed, or threaded like metal. Thus the manufacturer, with his cleverly designed molds, dies, and presses, is able to turn out a tremendous variety of plastic products that have come to play an important role in our everyday life.

Not least among the contributions of the plastics industry to human welfare is the use of abundant materials, thereby lessening the heavy drain upon our irreplaceable mineral resources. The domination of mind over matter wrought by the chemist has only begun!

28· Forests and Forest Products

1. THE DYNAMIC NATURE OF FOREST RESOURCES

The increasing usefulness of wood. Man cannot get along without wood. It has been useful in all stages of society, and the more civilization advances the greater is the service it renders. Man was not much more than an animal until he discovered the use of fire, and from far back in prehistoric time wood has served as fuel. Indeed, in many parts of rural America today firewood is a very common household fuel. Long before the modern era of coal and coke and electricity, charcoal made of wood was the great fuel in iron and steel manufacture, and in a few lands charcoal is still used in metal working. Perhaps as much as one tenth of the world's inanimate energy is now derived from firewood.

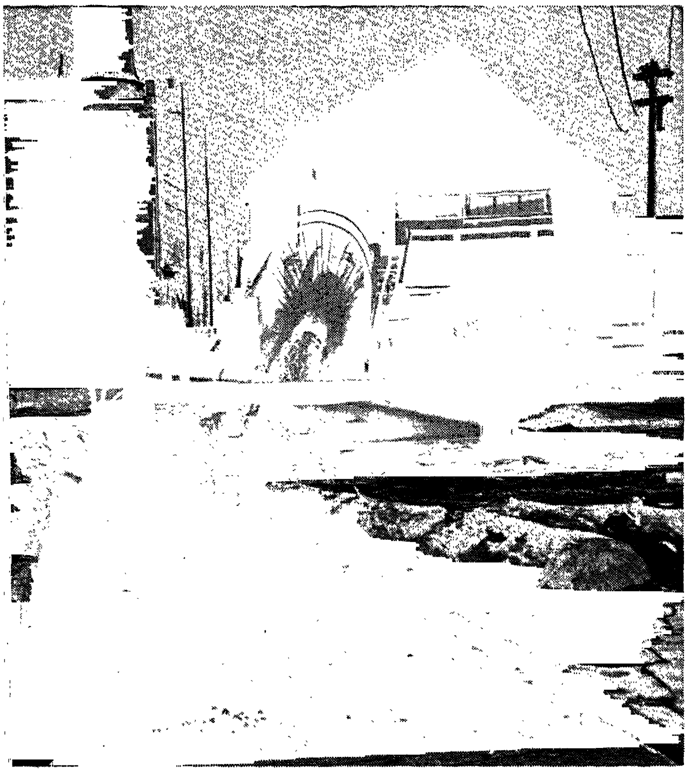
When man settled down to agriculture he used wood for his plow, for his house, for the barn to shelter his cattle, and for the fences that limit his land and keep his animals from wandering away. Down through the ages countless objects have been made of wood, which continues to serve as one of the world's prime building materials, particularly where it is plentiful. At the present time about two thirds of all lumber in the United States is used by the construction industry.

The movement of men and goods has long been facilitated by the use of wood in vehicles of transport, as in the sled, two-wheeled cart, wagon, ship, railway car, automobile, and airplane. For centuries prior to the modern era of cheap iron and steel, the hull and ribs of the world's ships were made of sturdy oak, the masts and spars being shaped from the lordly pine. To carry the world's goods hither and yon, surprising quantities of wood are needed for barrels, boxes, cartons, crates, and other containers. Today about 13% of the lumber output of the United States is used for containers, as compared with 44% during the war year of 1944.

Wood is indispensable in the diffusion of human knowledge. The printed page of nearly every book, magazine, and newspaper is paper, now made chiefly of pulp derived from cellulose, the hairlike fibers that comprise 65% to 80% of all wood. Cellulose is also a basic material in the manufacture of rayon, cellophane, alcohol, and many chemicals and plastics, while the soluble lignin of wood is used as a binder for plastics and has many chemical possibilities.

Other functions of the forest. The forest is something more than a source of wood. We are beginning to realize more keenly its use as a powerful check against soil erosion. Man is learning that gentle slopes should be planted in grain, that moderate slopes should be in grass, and that steep slopes must be in trees. Otherwise, our precious soil will wash away.

The forest is now being used as a vital agent in flood control. The forest floor is much like a sponge. A forested area has far less fluctua-



Easy moving of stored logs. Water under heavy pressure cleans them as they enter the mill. See Figure 25, bottom. *U. S. Forest Service*

tion in stream flow than a denuded area. No flood-control program—with its dams, levees, spillways, and channel straightening—can be truly effective unless the critical watershed areas are in trees.

Our national and state forests render great service in providing healthy relaxation for the denizens of our big cities. In the summertime the urbanite climbs into his car and frequently heads for the woods, where he can escape the crowds, noise, grime, and sweltering heat of the city.

In colder lands the virgin forest is valuable as the home of fur-bearing animals—the sable, ermine, mink, beaver, otter, and fox. In the vast Siberian forest and the Great North Woods of Canada the lonely trapper continues to hunt these valuable animals as he has for many generations.

In central Europe, southern Europe, and the Balkans the forest provides hog feed. A swineherd may drive as many as 600 hogs through a forest, the hogs consuming the acorns, beechnuts, and chestnuts to be found on the forest floor. In our southern Appalachian forests the razorback hog also roots for a living, but without guidance, and this rugged individual is better known for his speed, agility, and ferocity than for his pork-producing capacity, despite the excellence of acorn-fed ham.

In faraway tropic forests many natives spend their lives cutting hardwoods or gathering gums, nuts, rubber, chicle, rattans, and other products for shipment to the world's great market places. Other natives of the forest live in a subsistence economy and are engaged in hunting, fishing, and primitive farming.

Thus, forest resources mean many things. How forest land functions in the service of man depends not only upon the number of trees, the kind of trees, and other aspects of forest environment but also upon human wants and human abilities. These wants and abilities are constantly changing, and they vary greatly from place to place and from age to age.

2. FOREST DEPLETION AND THE MIGRATION OF LUMBERING IN THE UNITED STATES

The destruction of American forests. On every continent at one time or another, great tracts of primeval forest have stood as an impediment to the movement of man and the spread of agriculture. To the early settler in eastern America, the dense forest was an enemy as well as a friend, an obstacle as well as a resource, and his first effort was directed against the forest, which he worked laboriously to clear away before he could plant a crop. He then had to struggle for years with the stumps before he could have a smooth field to grow his food.

Decade after decade—through the seventeenth, eighteenth, and first half of the nineteenth centuries—the occupation of the country east of the Mississippi went steadily forward, accompanied by the destruction of the

forest to make room for the plow. In this process millions of fine trees were rolled into piles and burned to get rid of them, because at the time there was no accessible market where they could be sold. No people, past or present, ever destroyed their forests with such reckless abandon.

Regional shifts in lumber production. As the nation's population continued to grow, as the demand for lumber increased, and as transportation facilities improved, one tract of virgin forest after another yielded to the ax and the saw. The denudation of forests naturally began in New England, New York, Pennsylvania, and other eastern states, where the lumber industry was oldest and where the needs of dense population were great. In the early 1850's Chicago became the largest lumber market in the world, shipping vast quantities of Michigan and Wisconsin lumber through the Illinois and Michigan Canal[1] and later by rail to thousands of growing towns and cities and hundreds of thousands of farms on the treeless prairies of the upper Mississippi valley.

The first great shift in the center of lumber production occurred in the 1870's, when the output of Michigan, Wisconsin, and Minnesota surpassed that of the northeastern states. In the closing years of the century leadership in lumber production passed from the three Lake states to the South, and again in 1927 it shifted to the Pacific Coast, where it has remained (see Fig. 486).

For years the northeastern and Great Lakes states have been obliged to import lumber from other sections of the country, and combined production now amounts to only 8% of the nation's output. In the warm South, where trees grow most rapidly, the lumber industry is now almost entirely dependent upon second-growth timber. Only in the Far West do important and readily accessible stands of virgin timber remain. Of the nation's annual production of 35 to 40 billion board feet of lumber,

Thirteen years after the great Tillamook fire in western Oregon. Note auto. See Figure 484.
U. S. Forest Service

about 45% is now cut in Oregon, Washington, and California—or slightly more than the entire lumber output of a dozen southern states. The migration of lumbering into the Far West greatly lengthened the haul and increased the cost of transporting lumber to the great market east of the Mississippi and north of the Ohio and Potomac rivers, which normally consumes more than one half of all lumber used in the United States.

The end of an epoch. As a result of more than three centuries of tree slaughter, our heritage of forest land has been greatly reduced. It is estimated that the original forests of the United States covered 822 million acres and contained 5200 billion board feet of tim-

[1] This canal, opened in 1848, connected Chicago with La Salle at the head of navigation on the Illinois River. Lumber from Chicago was carried by boats traversing the inland waterways as far west as Lexington, Mo., and Fort Leavenworth, Kans.

Forest fire makes the future pay a fine—at hard labor. Planting little Douglas fir. No natural reproduction in 34 years after fire. Washington State. *U. S. Forest Service*

ber.[2] Today the nation has 461 million acres of forest land suitable for commercial use, containing 1600 billion board feet of timber in trees of sawlog size.

For many years we have been confronted with rising lumber prices. Between 1899 and 1949 the average mill price of southern yellow pine increased from \$8.46 to \$55.81 per 1000 board feet, while the price of western Douglas fir rose from \$8.67 to \$118.88. Other kinds of lumber had large increases in price.

For decade after decade the United States was the world's leading exporter of lumber, making large shipments to western Europe, eastern Asia, Australia, and Argentina. Since World War II the United States has become a net importer of lumber, our imports consisting chiefly of softwood lumber from Canada. In 1950 imports reached an all-time peak of 3½ billion board feet, the equivalent of 10% of our domestic production. In 1953 imports amounted to 2.8 billion board feet.

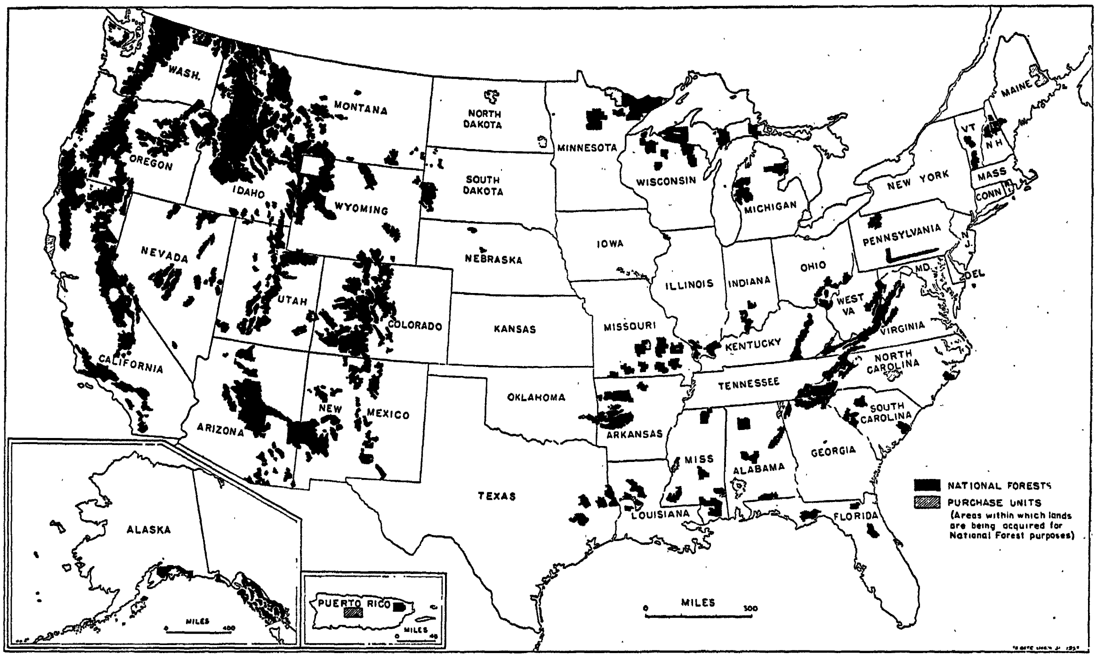
Wherever private enterprise and cut-throat competition prevail, the evolution of forest history in most nations is marked by three successive epochs: (1) wanton exploitation, forest cremation, and profligate waste; (2) dwindling supplies of local timber and increasing imports from other lands; and, ultimately (3) reforestation, conservation, and greater social control of forests. If the postwar import trend continues, the United States has entered the second epoch in forest history.

Throughout the past our lumbermen have found it expedient to cut their timber and reap their profit as soon as possible. This premium on haste and waste has been largely the result of the ever-present danger of fire, heavy taxes on forest land, high interest rates and the burden of a large capital investment with no financial return until the timber is cut, the existence of an "unlimited" supply of timber and the uncertainty of future demand, and a pathetic general lack of understanding of forest resources and forest problems.

In pitifully few instances have American lumbermen found it "worth while" to spend the time and money to make full use of the many products and by-products of wood and to cut timber selectively as a perennial harvest instead of stripping and abandoning the land. In the Pacific Northwest the Weyerhaeuser Timber Co. owns a forest empire of more than 2 million acres. This is divided into big plots that are cut in sequence, thus assuring a steady crop of trees every year. Only mature trees are cut. In 1951 the company set aside 203,000 acres of second-growth forest as a "tree farm" near Coos Bay, Oregon, and the company expects to harvest its timber crop about 2031 A.D.[3]

[2] Raphael Zon, "Forests," *Encyclopaedia of the Social Sciences,* The Macmillan Co., New York, 1931, Vol. 6, p. 383.

[3] "Woodman, Spare That Tree," *Time,* July 16, 1951, pp. 80–81. Another company has practiced scientific forestry profitably for many years on a tract of 400,000 acres at Crossett, Ark., and it makes full use of virtually everything in a tree. See J. Russell Smith and M. Ogden Phillips, *North America,* Harcourt, Brace & Co., New York, 1942, pp. 285–286.



U. S. national forests. East of the Great Plains, a record of slaughter; west, a monument to Gifford Pinchot and Theodore Roosevelt; other Presidents to a lesser extent. Compare with Figure 55 and note how closely the forests follow the mountain locations. *U. S. Forest Service*

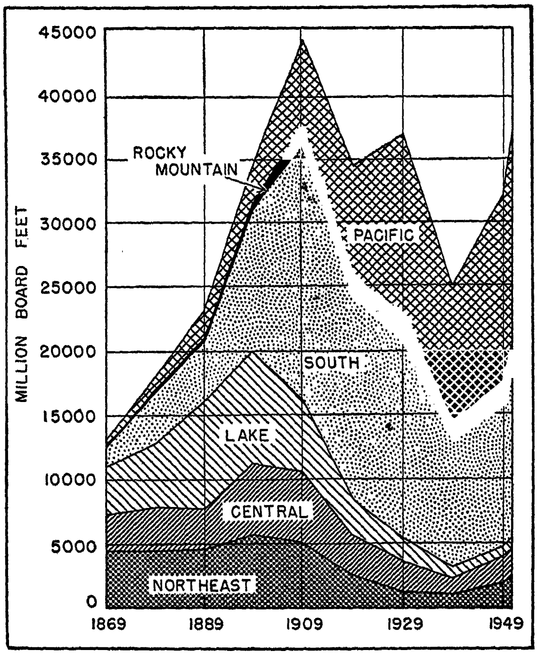
In 1929 we were cutting saw timber five times faster than we were growing it. Today the ratio of removal to new growth is about 1½ to 1. Although the gap between removal and new growth is now being narrowed appreciably, society must pay for the lumberman's expedient and tragic philosophy of "cut out and get out." When imported lumber becomes too costly, then scientific forestry on a large scale may begin. The years of indefinite plenty are gone.

Our national forests. Forest depletion received its first check in 1905, when the U. S. Forest Service was established and forest reserves, now called national forests, were placed under its management. The Forest Service permits the selective cutting of timber on a sustained yield basis; it allows livestock to be grazed where trees are large enough not to be damaged; it helps to maintain animal and fish life; it develops recreational facilities for the public; and it makes every effort to protect the forest against fire. This is wise use of public land (see Fig. 487).

The Forest Service now administers 181 million acres of land, an area greater than that of New England, New York, Pennsylvania, Ohio, Indiana, and Virginia combined. About 74 million acres are covered with forest suitable for commercial use. As Fig. 485 reveals, most of our national forest land is in the Rocky Mountain and Pacific states. In the interests of the American people, these national forest lands must be preserved.

3. THE LUMBER INDUSTRY IN THE UNITED STATES

Improvements in lumbering. The Machine Age has come to the forest. Lumberjacks equipped with axes and crosscut saws are still used in large numbers, but more and more trees are being felled with power saws. At one time horses, mules, sleds, and wagons were commonly used to move the heavy logs from the heart of the forest to the nearest railroad or waterway, but these have almost entirely given way to the caterpillar tractor and motor truck. The picturesque and dangerous log



U. S. lumber cut by regions. Skinning the continent: board feet per capita 1909, 495; 1929, 302; 1949, 216. Will it ever increase?

drives on New England streams in the springtime are almost a thing of the past.

In the early years of forest clearance the necessary lumber for local use was cut in a little sawmill adjacent to a waterfall, the waterwheel driving a big upright saw up and down, ripping off boards for the man who brought his logs to the mill. In the modern era of steam, electricity, and gasoline a sawmill can be located almost anywhere. The small sawmill, equipped with a circular saw and operated by a few men, can move from place to place. In the big mills the circular saw has given way to the rapid double-cutting band saw, and mechanical devices handle the logs and carry them to the saw blades with unvarying precision and speed.

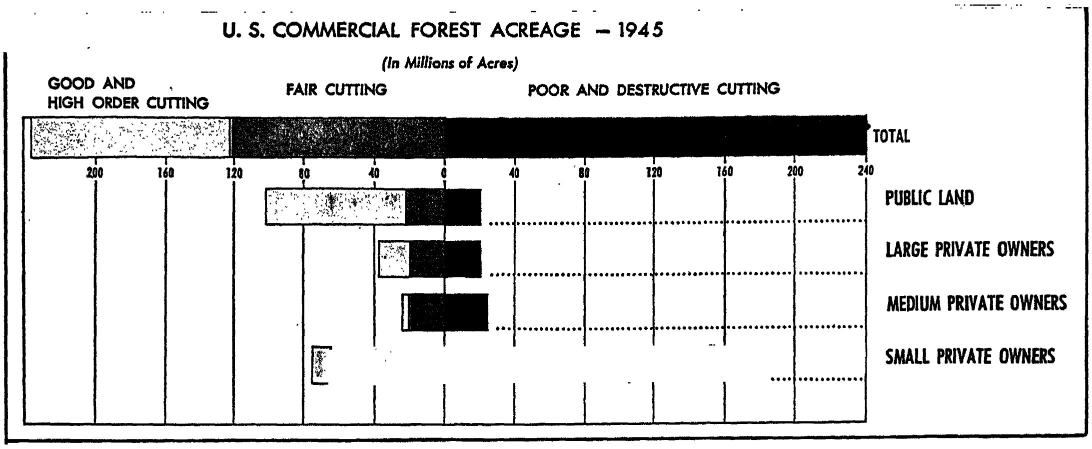
Lumber production in the North. The Middle Atlantic, New England, Lake, and Central states, in order of importance, together account for about 12% of the nation's lumber output. Production is concentrated very largely in two areas: (1) the rugged Appalachian highlands, from upper New England and northern New York southward into West Virginia and Kentucky, and (2) the glaciated and generally infertile lands of northern Michigan, Wisconsin, and Minnesota. These areas are land that is unfit for the plow. It is land that should remain forever in forest.

The most important tree in New England was originally the white pine, prized for its lightness, strength, durability, freedom from warping, cracking, shrinking or splintering, and the ease with which it can be worked.[4] First the lumberman took the virgin pine; then spruce, hemlock, fir, the second-growth pine—this cycle being repeated in New York and the Lake states. Today the pine and hemlock are outnumbered by the spruce, balsam fir, beech, birch, and maple. In the Middle Atlantic and Lake states the beech, birch, and maple predominate. The sturdy oak remains of major importance in the Middle Atlantic and Central states. Most of the trees being cut in northern forests are short stuff for the pulp and paper mill.

Lumbering in the South. The southern states now produce about 36% of the nation's lumber. This section of the country is endowed with unusual advantages for lumbering. Its location enables it to serve the great market in the northeastern quarter of the country more easily than its rival, the Pacific Northwest. Most of the South is level or gently rolling, and lumbering is much easier than in the Appalachian highlands and the rugged mountains of the Pacific states. No section of the country can equal the warm and rainy South, particularly the Gulf states, in rapidity of tree growth. In Maine a red spruce is only 1.8 inches in diameter after 70 years of growth, while loblolly pines in east Texas average 24 inches at the same age. Indeed, southern loblolly and slash pine are ready for the pulp and paper mill at the tender age of seven to nine years.

The South is endowed with a variety of

[4] "God made the pine," says the carpenter, but when he pulls a splinter from his thumb, "The Devil made the hemlock." Hickory and oak, strong and heavy, offer great contrast to the beloved white pine.



The record of cut out and get out. Higher price forces some change, but most small owners think that trees are like wild rabbits. ***The President's Materials Policy Commission, Vol. I***

softwoods and hardwoods.[5] The yellow pine, long a great building material, is by far the most important and widespread species, the total stand of sawlog size amounting to over 230 billion board feet. The oak ranks second, followed by the sweet gum and the tupelo and black gums. Other important species include the long-lasting cypress of the Gulf Coast swamplands, the long-leaf and slash pines that supply rosin and turpentine, and the loblolly and short-leaf pines used in making wood pulp for newsprint. Of the original vast expanse of virgin forest, not more than 10% remains.

Lumber production in the West. The states of Oregon, Washington, and California have nearly 60% of the nation's timber reserves, and they account for about 45% of the lumber output, each of these states producing more than 3½ billion board feet of lumber a year. Idaho, with an annual output of nearly 1 billion board feet, is the only important lumber producer among the Rocky Mountain states. Lumbering is of outstanding importance in the Cascades, Klamath Mountains, northern Sierra Nevada, and the Coast Range.

In the Pacific Northwest the Douglas fir is the leading species, the total stand of sawlog size amounting to 331 billion board feet. Other major species are the western hemlock, ponderosa pine, fir, larch, sugar and white pine, and spruce. With the exception of hemlock and larch, northern California is well supplied with these trees. California alone among our 48 states is a producer of the giant redwood, which is found in the Coast Range north of San Francisco and on the slopes of the Sierra Nevada.

The Pacific states are the home of big trees, the result of centuries of growth. The thick stand of trees in the rainy Pacific Northwest is known as "overmature growth." This section of the country is also the home of big lumber companies, such as Weyerhaeuser, Long-Bell, and Crown-Zellerbach. Weyerhaeuser, the nation's largest lumber company, sells as much as $275 million worth of lumber a year. However, no single company or group of companies dominates the U. S. lumber industry, as the eight largest companies have less than 10% of the total lumber business.[6]

[5] Principal commercial woods as classified by the U. S. Forest Service:

	Softwoods	
pine	spruce	cedar
fir	cypress	larch
hemlock	redwood	tamarack
	Hardwoods	
oak	beech	ash
maple	birch	hickory
poplar	basswood	walnut
gum	elm	sycamore
chestnut	cottonwood	cherry

[6] Edward L. Allen, *Economics of American Manufacturing,* Henry Holt & Co., New York, 1952, p. 222.

4. CANADIAN AND ALASKAN FORESTS

The forests of Canada. Forest land, some 1,320,000 square miles in extent, accounts for nearly 40% of the total land area of the Dominion of Canada, including Labrador and Newfoundland. Nearly 40% of the existing forest consists of small trees that will never reach merchantable size, because the trees are growing on poorly drained land or at high altitudes or are subject to other adverse conditions. More than half of all merchantable timber is beyond the reach of any economic mode of transportation.[7]

Nature sets the limits of the vast Canadian forest. On the north the winters are so cold that trees shrink to the size of creeping vines and give way to the bushes, mosses, and lichens of the Arctic tundra. On the northeast the tundra reaches south along the Labrador coast to Hamilton Inlet, and along the coasts of southern Labrador and Newfoundland the trees are very small. Within the Rockies at lofty altitudes are "islands" where trees give way to Alpine vegetation, which in turn gives way at higher elevations to snow and ice, these islands increasing in size as one goes north. On the south the forest reaches the United States border, with the exception of prairie grassland between the Red River and the Rockies and other areas now devoted to farming.

Years ago much forest land in southern Canada was cleared for agricultural and industrial use. Such was the case of the better lands in the Maritime provinces, the St. Lawrence and Ottawa valleys, the Ontario Peninsula, southern Vancouver Island, and a number of other areas.

Softwoods comprise 80% of all standing timber and account for about 70% of all wood that is cut. Groves of aspen adjoin the wheat belt that was once grassland in the prairie provinces, but elsewhere in southern Canada the trees are much like those in adjacent areas of the United States. In the northern part of the forest, next to the tundra, the dominant species are spruce, balsam fir, poplar, and jackpine.

Most lumbering occurs along the southern and more accessible edge of the Canadian forest. Only two railroads extend northward through the woods to Hudson Bay.[8] The forest is sprinkled with lakes, marshes, swamps, and areas of bare rock. Most of it is little used except by a few Indians, fur trappers, miners, and summer fishermen.

In the present excitement over gushing oil wells, newly discovered ores, expanding factories, new power projects, and bumper wheat crops, many Canadians tend to forget that their largest industry is still based upon trees. Sawmill products are worth more than $500 million a year, while the pulp and paper industry has an output worth over $1225 million. In 1953 Canada accounted for 53% of the world's production of 10,877,000 tons of newsprint.

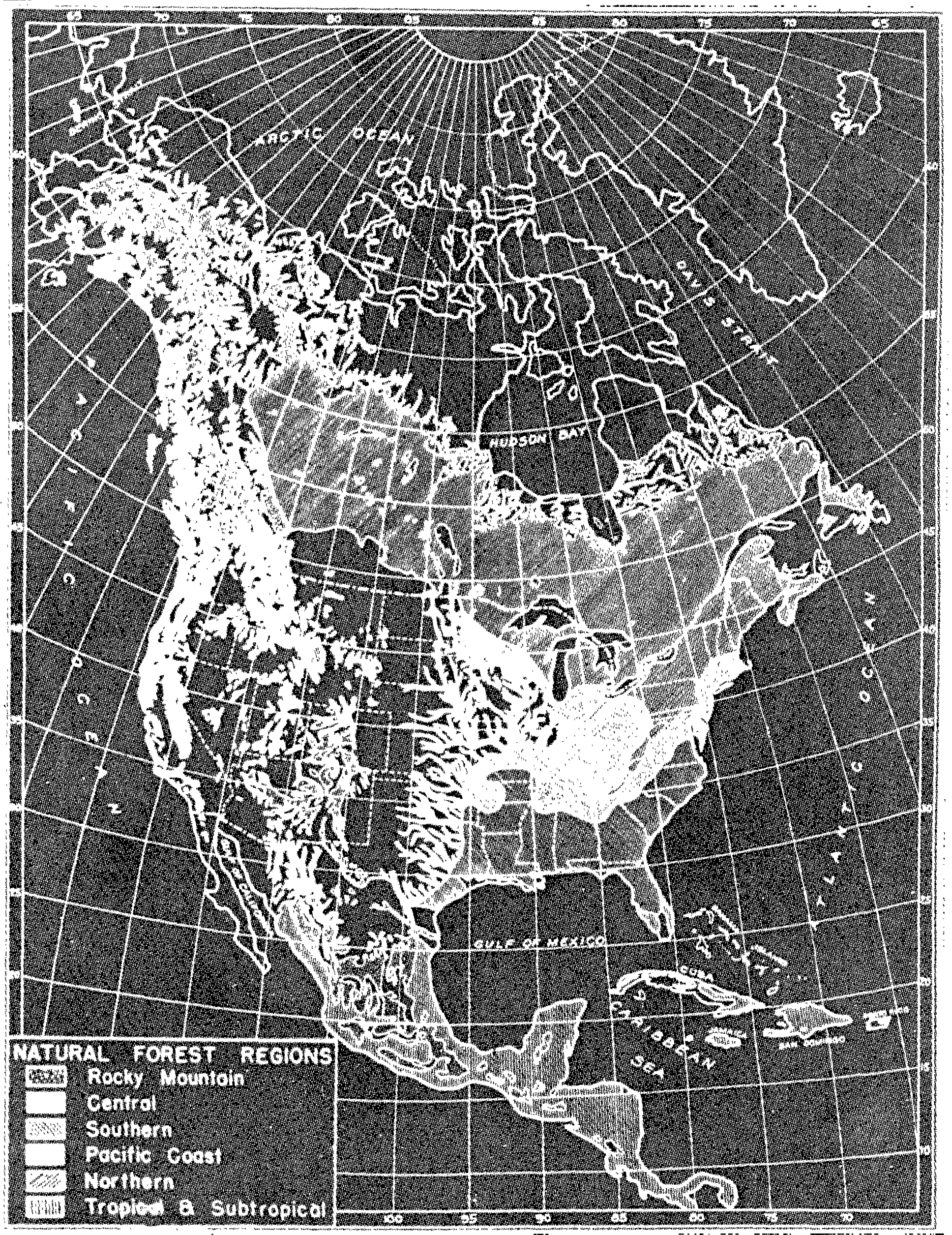
Canadian forest policy and experience. In Canada, as in this country, the public forest lands are well managed, the government pursuing a policy of licensing timber-cutting rights, mining, water-power development, and grazing, hunting, and fishing privileges. About 90% of all forest land in Canada, excepting the Maritime provinces, belongs to the Crown, and in this vast public domain the vicious cycle of cut, slash, fire, and land abandonment has not been allowed to run its dismal course.

On privately owned lands Canadian lumbermen have pursued the virgin forest westward, just as ours have done, and today most of the dominion's lumber is produced in British Columbia, much of the remainder being cut in Ontario and Quebec. In the vast expanse of Canadian forest the greatest of all hazards is fire.

---

[7] Dominion Bureau of Statistics, *The Canada Year Book, 1950*, Ottawa, 1950, pp. 458, 460, and American Geographical Society, "The Outlook for Wood," *Focus*, November 15, 1951, p. 5. Aerial photographic surveys have revealed large interstream areas without timber, and early estimates of forest land have been reduced. Little is known about the forest of Labrador.

[8] These little-used railroads, extending to the ports of Churchill and Moosonee, are discussed in Chapter 33.



This splendid map of natural forest lands should be compared with the Mercator map, Figure 494. In considering the vast area of Canadian and Alaskan forests you should note that the northern limits do not merit the name forest, if saw timber is a part of your concept. There is tree growth—some tree growth, yes—but saw logs? Or commercial access? *Baum's Atlas of U. S. A. Electric Power Industry*

Alaskan forests. The forests of Alaska are a continuation of those of British Columbia, and those of British Columbia are a continuation of those of adjacent parts of the United States. In the southern part of Alaska, especially on the rather narrow Pacific slope, there is heavy rainfall with a dense stand of good western hemlock, Sitka spruce, and cedar—which fortunately is owned by the United States government. The Tongass National Forest in southeastern Alaska and the Chugach National Forest along Prince William

Sound contain 87 billion board feet of timber, three fourths of which is within 2½ miles of tidewater and which some day may be cut under government control.[9]

In 1947 Congress passed a law permitting the sale of Tongass timber, with cutting under the supervision of the U. S. Forest Service. In 1953 Alaska's first pulp mill was under construction at Ward Cove near Ketchikan, a joint venture of the American Viscose Corp. and the Puget Sound Pulp & Paper Co. A plywood mill, owned by the Columbia Lumber Co., in Juneau was nearly ready for operation.[10] Other projects were being planned. These developments in Alaska clearly reveal our insatiable demand for wood.

In the interior of Alaska along most streams is to be found some good timber, which is used as fuel and building material in the small permanent communities and which long has served as fuel in the operation of river steamboats and for building cabins and as fuel by hunters, fishermen, miners, and prospectors for gold. The large and dry interstream areas of the interior, however, support only a stunted and sparse tree growth, while the bleak tundra of northern and western Alaska has no trees at all.

5. THE INTENSIVE UTILIZATION OF EUROPEAN FORESTS

Comparison of European and American timber conditions. Europe, having nearly four times as many people as the United States and Canada, and having been much longer occupied by a large population, has very different forest conditions. The American settlers found a continent covered with the forest growth of centuries, which they have cleared to get at the earth in desirable localities and have elsewhere cut recklessly and with no regard to the future. While a scarcity threatens the United States, Europe has long felt it in the form of high prices and is raising timber as carefully as she raises food. In western Europe the annual lumber consumption per capita is only about one fourth that of this country.[11] Between 1905 and 1953 the use of lumber in the United States declined from 506 to 254 board feet per capita. That is a simple fact, but it cuts deep.

This European economy involves many practices unknown in new forested countries. The American people annually destroy tens of millions of barrels, boxes, and crates that often are used but once, these containers being made of sawed lumber with all the waste this involves. In Europe packages are often used repeatedly and are very often baskets made of round or split twigs of willow which is grown for the purpose. The willow trees are planted in wet ground and repeatedly cut off when 5 or 6 feet high so that the stubby trunk with its great load of long twigs yields repeated harvests of basket material. Reeds resembling bamboos are also planted in the south of France and other European localities for package material.

Frame houses have been built by hundreds of thousands all over the United States and Canada, while many people in central Germany never in all their lives saw a frame house. It is decidedly cheaper there to build one of brick, stone, or plastering put upon a wooden framework. This framework is often of unsawed poles made from small trees, rather than the sawed material from large trees as in the United States. Reeds from the stream bank often replace in Germany the plastering lath used in America. This house made of reeds, poles, and plaster illustrates Europe's economy of wood. In forested mountain districts the European often uses wood as shown by the well-known Swiss chalet. This form of

[9] It is estimated that the Tongass Forest under scientific management can produce not less than 1½ million cords of pulpwood annually in perpetuity that would yield 1 million tons of newsprint paper, or about one fourth of the annual newsprint requirements of the United States. National Resources Committee, *Regional Planning, Part VII, Alaska, Its Resources and Development,* Washington, December 1937, pp. 100–101.

[10] "Alaska's Timber: Tapping of Rich Forest Breeds a Batch of New Wood-Products Plants," *The Wall Street Journal,* June 20, 1953, pp. 1–2.

[11] American Geographical Society, *op. cit.,* p. 4. See United Nations, *European Timber Trends and Prospects,* New York, 1953.

house seems to be a mountain institution, as it exists also in the southern part of the Near East and on the southern slope of the Himalayas.

In Europe, particularly in Germany, intensive use is made not only of wood but of its various derivatives. During World War II German armies were clad in wood "wool" and were fed on the meat of pulp-fed cattle and on supplementary protein rations derived from wood. Many motor trucks were lubricated with tree-stump oil, and they rolled on synthetic rubber tires made from alcohol obtained from wood. So numerous and useful are the by-products of wood that the Germans often refer to wood as the *universalrohstoff*, or universal raw material.

European timber markets and exporters. All Europe north of the Mediterranean slopes is naturally a forest country. In Great Britain, however, only 4% of the land remains in forest. The needs of tillage have not caused such complete clearance of the North Central Plain, which reaches from northwestern France through north Germany and central Russia to the Urals, and where considerable areas of sand are suited to little but pine forest. The Netherlands with 7% of its land area in forest, Belgium with 18%, and well-tilled little Denmark with 8% have put their arable land to the plow and must import nearly all their timber.

Only eight countries in Europe have a surplus—namely, Finland, Norway, Sweden, the Soviet Union, Austria, Yugoslavia, Poland, and Rumania. Norway, Sweden, and Finland are, like New England and Canada, glaciated, mountainous, populated only in spots, and with but a small proportion of their land good for anything but the growth of trees or forests, which assume a very important place in the foreign trade of these countries. In Norway 73½% of the total area is unproductive, 23% is in forest, only 2½% is arable land, and about 1% is in meadow and pasture. Forest products make up over 26% of the exports. In Sweden, 60% of the land area is in forest. As in North America, where the forests of Canada extend east and west across the continent, so in Europe the forests of Norway, Sweden, and the Baltic States are continued eastward across Finland and onward across the Soviet Union.

Thrifty Finland has 70% of her land area covered with forests, chiefly spruce and pine. Each spring with the melting of the snow, the Finnish and Swedish streams carry their burden of logs down to the sea, and upon the melting of the fields of ice in the Baltic whole fleets of tramp ships hasten to the Gulfs of Bothnia and Finland to load cargoes of lumber, mine props, pulp, and paper from the many sawmills, paper mills, and log drives. Wood, pulp, and paper furnish 80% of the exports of Finland and promise to hold this leadership.

The largest coniferous forest in Europe today stretches across the Soviet Union north of 60°N. Lat. and contains a splendid stand of Norwegian spruce, Scotch pine, fir, and larch, with some birch, alder, and willow. In this cold region tree growth is slow, 18-inch logs often being cut from trees 150 to 175 years old. During the summer millions of logs are rafted down the great northward-flowing rivers.

Murmansk on the Barents Sea, Archangel on the White Sea, Mezen on the lower Mezen River, and Igarka on the lower Yenisei River have become important sawmill centers and exporters of lumber, Murmansk being the only ice-free port. Powerful icebreakers maintain an open channel to Archangel throughout most of the winter. Such ports as Igarka have a very short navigation season in summer, and icebreakers are frequently used. Considerable lumber is also shipped through the Baltic and White Sea Canal. Soviet lumber exports to Great Britain and other timber-poor countries of western Europe have increased greatly in recent years.

Forest policy in central and northern Europe. The scarcity of wood, which has caused the European nations to preserve their timber and practice forestry, has often driven the federal, state, and municipal governments

into the lumber business. Nearly all the governments own forests and care for them as part of their administration. As a result France has 22% of her area covered with forests, Germany 27%, and Switzerland 25%. In the U.S.S.R., it is 44%.

In France various governmental units now own and operate over 37% of the forests. Within a century an area of shifting sand dunes and marshes in the southwest of France, twice as large as the state of Delaware, has been turned into a profitable pine forest, yielding rosin, tar, pitch, turpentine, and other products.

Scientific forestry in Europe. It is to Europe that we must go for the best examples of well-managed forests that are producing their maximum output. There we can learn how to make our own forests permanently meet our needs. In densely peopled localities the trees are often planted as thickly as hills of corn in the United States—which is about 4 feet apart. When the trees are 1½ to 2½ inches in diameter, some are cut for use as bean poles, hop poles, fence palings, etc., while later thinnings furnish poles for firewood and many other uses, including part of the framework of the plaster houses. At the end of 100 years or more, after many thinnings, the forest contains only big trees that can be sawn into boards and building timber, after which the forest is replanted, to go through the same cycle of harvests. Many German and Swedish towns own adjacent forests that are carefully managed and furnish the towns with a large part of their revenues.

There are several different systems of handling forests in Europe, each suiting some specific kind of forest or condition of marketing the product. But even under scientific forestry France, Germany, and Switzerland, with their relatively large percentage of well-managed forests, are not able to supply their own needs even with small consumption.

The importance of forests and forestry is shown in the mountains of Switzerland and the Black Forest district of south Germany, where wood carving is an important industry of the peasants in the winter season, and their wooden toys and curios are exported throughout the Western World.

The forests of Mediterranean countries. In Europe, as in North America, the coniferous trees comprise the bulk of northern forests, while the oak comes from lower latitudes growing in Spain, Italy, Hungary, and the Balkan peninsula. In Yugoslavia the oak trees on the highlands, which comprise most of that country, furnish in their acorns one of the leading crops—harvested by swine.[12]

There are practically no forest resources of importance along the southern or western shores of the Mediterranean; and the dry summer of Spain, Portugal, Italy, Greece, and Turkey limits tree growth to the mountains with their greater rainfall, and leaves each of these countries with an insufficient supply of lumber. Houses are almost invariably built of earth materials (mostly stone and plaster), and, as these countries are barren of coal and populous with poor people, many of the inhabitants suffer keenly from cold in the winter season. If you want to shiver, go to "sunny" Italy or Spain in the winter.

Italy, having, like France, lost good lands from unwise deforestation, has also been planting forests. Italy consumes only one seventh as much fuelwood per capita as timber-rich Canada, while the ratio for lumber is 1 to 16.[13]

Cork, the principal forest export of southern Europe, is the tough outer bark of a kind of oak growing upon the highlands of Portugal, Spain, southern France, and the mountain ranges of North Africa running through Morocco, Tunisia, and Algeria. The bark can be stripped repeatedly from the trees at intervals of a few years. Portugal is by far the leading exporter of cork. Annual Portuguese exports of cork and cork manufactures amount to 160,000 tons, as compared with 64,000 tons from Spain, 64,000 tons from Algeria, and 34,000 tons from French Mor-

[12] See Earl B. Shaw, "Geography of Mast Feeding," *Economic Geography,* July 1940, pp. 233–249, and J. Russell Smith, *Tree Crops,* Devin-Adair, 1953.

[13] American Geographical Society, *op. cit.*

occo. The cork oak has been planted experimentally in California and some of our southern states. As yet our entire supply of cork is imported—but we can grow it.

6. FORESTS IN THE TEMPERATE LANDS OF ASIA AND THE SOUTHERN HEMISPHERE

Japan's forest industries. Japan is a country which, from necessity, takes excellent care of its forests. Because of the mountainous nature of the country and heavy rainfall, forests cover 70% of the land area of Japan. The forests have long furnished domestic fuel and building material for a dense population, Japan proper now having 85 million people on 147,700 square miles.

Since her industrial revolution, Japan has opened up previously unused oak forests on the colder and less intensively used north island, Hokkaido. But this does not meet her growing needs, and for some years Japan has imported timber from the Pacific coast of Canada and the United States. Now that U. S. lumber exports are dwindling, Japan may turn to the Soviet Union for a part of her supply.

In bamboo, lacquer, and camphor Japan has three forest products that are distinctly Oriental. The bamboo is probably the most important Japanese tree. It is planted and cared for like a field crop and fills a multitude of uses. With bamboo it is said that the ingenious Japanese can build an entire house—framework, floor, walls, and roof—while its large joints serve as buckets and other utensils in great variety, and the young shoots serve as food. The lacquer, that beautiful varnish which we see on the glossy lacquerware, is made from the sap of the lacquer tree. The camphor is a kind of resin distilled from the wood of the camphor laurel tree.

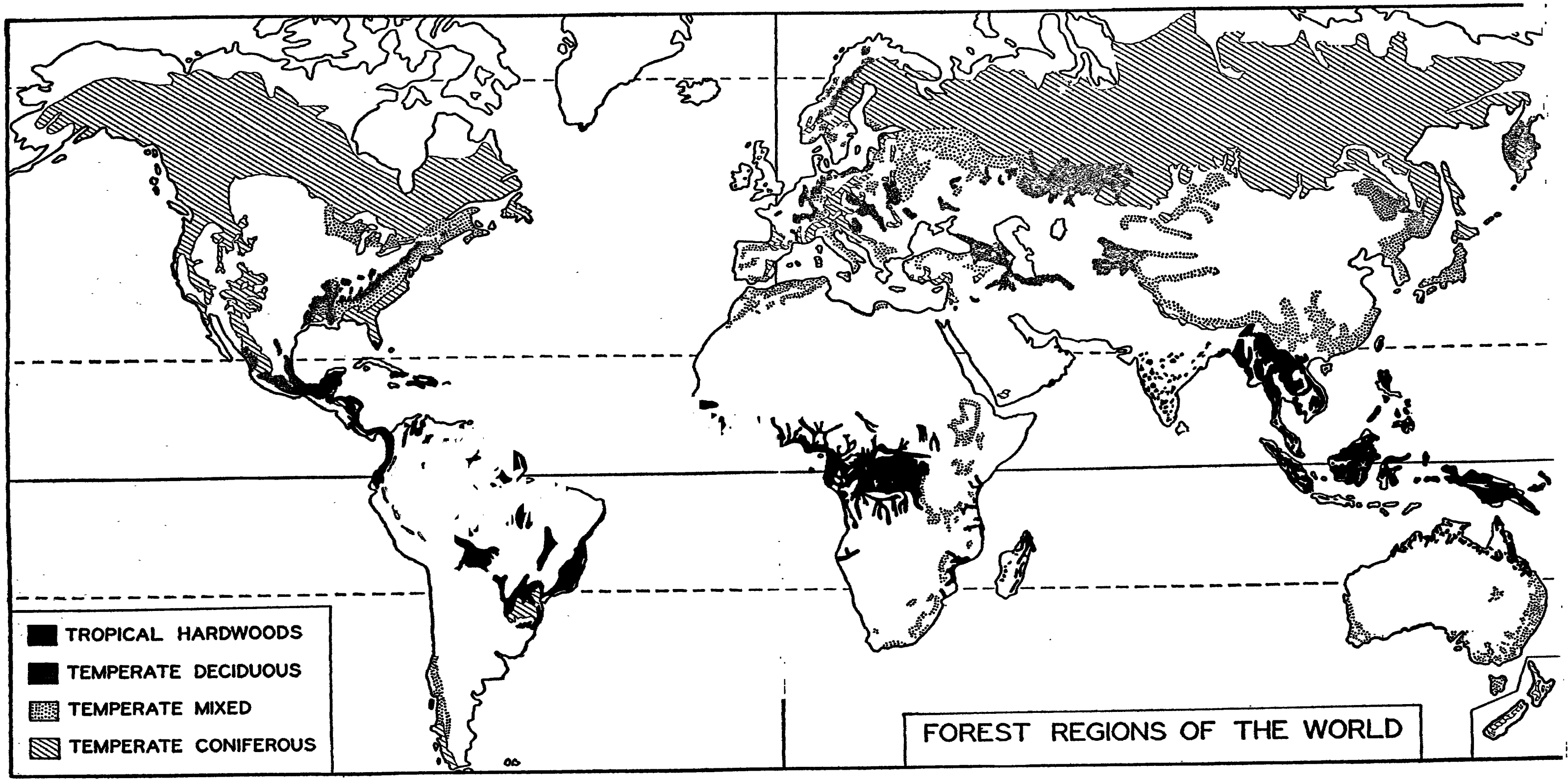
Three fourths of the world's supply of natural camphor is obtained from the island of Formosa, which is now held by Nationalist China. The Fukien province of China, the islands of Shikoku and Kiushu in Japan, Indochina, Sumatra, Java, and Borneo also contribute one or more kinds of camphor to the world's market. Prior to World War II, the United States imported more than 1 million pounds of camphor annually, but most of our camphor is now obtained synthetically from turpentine.

Forests in China. The Chinese forest situation is far inferior to that of Japan. In some districts her dense population long ago used all the forests and often dug up roots, with frightful results in floods and denudation. In many sections of the country her people raise a small amount of fuel for domestic use in the form of the stalks of a coarse millet, while considerable parts of China have been irreparably injured by the cutting of the forests and washing of rocky mountain earth over the fields in the erstwhile fertile valleys. A scientific forest policy is undoubtedly one of the most pressing needs of the government, and one of the most difficult for it to bring about. In prewar years China ranked fifth among foreign markets for U. S. lumber.

The Siberian forest. As Canada holds a great forest reserve in North America, so the corresponding parts of Siberia promise to serve that continent. About 11% of the world's timber is cut in the Soviet Union, which possesses 21% of the world's timber lands or a forested area of 1,527,300,000 acres, four fifths of which is located in Asia.[14] Much of the Amur River Basin is useless for agriculture as we now know it, but, like upper New England, Newfoundland, and Quebec, good for forests. The Siberian forest is the real hope of Asiatic peoples for a nearby timber supply, and it constitutes the world's largest little-used reserve.

Now that the airplane and icebreaker are enabling ships to find their way through the Arctic with greater ease, there is new possibility of marketing Siberian timber.

[14] Of the total forest area, about 62% is suitable for commercial exploitation. Pine and spruce account for nine tenths of the conifers, while birch and aspen represent about eight tenths of the deciduous trees. George B. Cressey, *Asia's Lands and Peoples*, McGraw-Hill Book Co., New York, 1951, p. 325.



Anyone looking at this map should remember that it is on the Mercator projection with its gross exaggeration of areas in high latitudes. He should look at once at a homolosine, such as the world climate regions in the front of this book, to correct this erroneous impression.

Perhaps Africa contains the greatest surprise. A good many people think it is mostly either jungle or Sahara. Of the two it is more Sahara than jungle. The areas of tropic grassland adjacent to the main tropic forest belts have transition zones of brush and scrub that are neither forest nor grass. True also of much land in India. *From Jones and Darkenwald, Economic Geography, The Macmillan Co.*

Forests of the Southern Hemisphere. The temperate forests of the Southern Hemisphere are but pygmies in size when compared with those of North America and Eurasia, a contrast resulting from the fact that (1) the land area of the South Temperate Zone is much smaller than that of the North Temperate Zone and that (2) most land south of the Tropic of Capricorn is too dry for good tree growth.[15] While forests in the temperate lands of the Southern Hemisphere are of local importance, they supply a very small part of the world's timber.

The largest, best, and most accessible softwood forest in all South America covers about 100 million acres of rolling uplands in the states of Paraná, Santa Catarina, and Rio Grande do Sul that lie in the southern and coolest part of Brazil. This forest, with about 800 billion board feet of timber in reserve, contains large and unmixed stands of excellent Paraná pine, many of the trees ranging from 80 to 120 feet in height. Modern sawmills, equipped with U. S. machinery, are now in operation, about two thirds of the lumber being used in Brazil, especially in the more populous states of São Paulo and Rio de Janeiro. The remainder is exported, chiefly through the port of Paranaguá, to the treeless pampas of eastern Argentina and adjoining Uruguay. (Compare U. S. on colored map.)

Temperate-zone forests of Argentina lie at the base of the Andes in Patagonia. They lack adequate transportation facilities and are little used, for they are inaccessible to the markets of the eastern pampa where three fourths of the nation's people live. Hence, Argentina is the leading lumber importer of South America, obtaining its supply from Brazil and Canada. In Chile about 700 small sawmills operate in the cool, moist, and rugged forest land south of Puerto Montt. The Chilean forest contains about 175 billion board feet of wood in trees 11 inches or more in diameter. Chile is virtually self-sufficient in wood.

Since less than 1% of the Union of South Africa has a forest cover, mainly along the south coast, the nation is vitally dependent upon lumber imported from our southern states and from the Baltic countries. The chief forest export is wattle bark, which yields an extract used in the tanning of leather.

In the southeastern and southwestern parts of Australia and on the island of Tasmania are hardwood forests that cover about 1% of the nation's area. Each year Australia must import more than $30 million worth of lumber and $50 million worth of paper, chiefly from Canada and Scandinavia. Among Australia's limited forest exports are two hardwoods that are unusually resistant to moisture, the ravages of insects, and decay: karri wood, which is used to pave bridges and streets in western Europe, and jarrah wood, which is commonly used for piles in wharf construction in many a seaport throughout the world. The forests of New Zealand are much better than those of Australia, containing various pines and the well-known gum-bearing kauri, but rapid cutting threatens the existence of the lumber industry, and only one fifth of the original stand of timber now remains.

7. THE TROPIC FOREST AND ITS PRODUCTS

The relative unimportance of tropic forests. The torrid zone contains a larger area of forest than do the temperate zones. Tropic woods are in great variety, and many are of surprising beauty and hardness. But the forests upon the whole are very much less valuable than those of the cooler north with its less favorable conditions for the growth of vegetation.

The relative uselessness of the tropical forests is owing to poor quality and inaccessi-

[15] Look at the globe. Notice how South America and Africa taper off to the south, and see how little of the world's land area lies south of the Tropic of Capricorn. Compare the natural vegetation and rainfall maps that are drawn on homolosine equal-area projections in *Goode's World Atlas*. Observe the location and size of the Atacama, Kalahari, Gibson, and Great Victoria deserts. Note the areas in the South Temperate Zone that will support only sagebrush, thorn scrub, and prairie grass and the much smaller areas where moisture permits forest growth.

bility. Many trees of the tropic forest are crooked and useless for lumber. Often they are worthlessly soft and weak, and the good ones are almost always mingled with many other species.

For example, an acre of land may contain only one mahogany tree in the midst of a great number of useless trees. This mixture of species is a striking and important contrast to the practically solid stand that exists in the pine or spruce forests of Maine, the pine of Mississippi, the fir of Washington, the cypress of Louisiana, or the oak of West Virginia.

To make matters worse, the heavy rainfall and heat produce such a wealth of bushes, small trees, and vines that in many areas a man can only force his way through by first cutting a path. Thus the *machete,* a long-handled knife, is the most universal tool possessed by the inhabitants of many tropical countries. With it they cut paths through the forest in which each tree is often bound by creepers to a dozen others, so that the felling of one tree is a most difficult process. As the jungle is often swampy, it is evident that a wagon can rarely enter to carry logs; its wheels would sink into the soft earth even if roadways could be cut.

The nearest approach to the northern blessing of snow with its sled transportation is the annual floods of the rainy season, which permit the floating out of those logs that grow on overflowed land and are light enough to float. Those that are heavier than water—and most tropical cabinet woods with their great strength and beauty are heavier than water—must rot where they grow or be dragged out at great expense. Consequently, the chief timbers exported from the tropics are the buoyant mahogany and Spanish cedar. (For the location of tropic forests, see Region No. 2 on the colored map of climatic regions at the front of the book.)

The Philippine Islands provide a good example of the low commercial value of tropic forests. The botanists tell us that more than 100 species of useful woods are to be found in the islands, which are largely covered with forests belonging to the government. It is not the number of species, however, but the goodness and cheapness that make them valuable. Nine species of trees—namely, yellow pine, Douglas fir, white pine, hemlock, western pine, spruce, cypress, the oak, and maple—have furnished 95% of our timber and made the United States the greatest timber producer in the world. Despite their riches in forest area and number of varieties, the Philippine Islands have only a small export of cabinet woods.

The woods exported from the tropics. Mahogany, the most important wood exported from the tropics, is hard[16] and strong, takes a beautiful finish, and is much prized for furniture and interior work. The mahogany hunter, climbing one mahogany tree, looks across the forest to locate the next one towering above the level green, and then cuts his way to it. Mahogany is light enough to float and valuable enough to be hauled out of some locations where there are no floods to float it. The best mahogany is shipped from Haiti and the Dominican Republic, while other mahoganies come from British Honduras, Mexico, Honduras, Cuba, and Brazil. African mahogany, a slightly different species, is shipped in large quantities from coast ports between the Gold Coast and the Cameroons in West Africa.

Spanish cedar, the second tropical wood in commercial importance, exists in many varieties, exported chiefly from the West Indies, and the Gulf coasts of Mexico and Central America. Two of the chief users of this soft light wood are the makers of cigar boxes and pencils.

The third of the tropic woods is teak, a wood that resembles oak in its physical characteristics. But teak is much more valuable than oak for shipbuilding, because, unlike oak, it contains an oily substance that acts as a preservative and when in contact with iron

[16] Mahogany is really intermediate wood, being softer than oak, elm, or even birch but harder than yellow pine or Douglas fir. In strength and specific gravity tests it is almost identical with our red gum.

causes it to deteriorate much less rapidly from rust than do oak and other woods. Teak grows in the forests of southeastern Asia from India to China and has been planted for timber purposes in Java. The chief supply of commerce comes from Burma, where it is floated down the Irrawaddy River to Rangoon, down the Salween to Moulmein; and from Siam, where the Menam River floats the valuable logs down to Bangkok for shipment. As Britain is the greatest shipbuilding nation in the world, she imports most of the teak.

Tropic imports of temperate zone woods. It is true that some tropical timbers have great hardness, strength, durability, and beauty, but many of them are so hard that tools will scarcely work them. Furthermore, their inaccessibility makes them as useless as the millions of tons of excellent building stone that lie valueless in the heart of every mountain region far from growing cities. Despite the riches of millions of square miles of jungle and forest lands, temperate-zone lumber is imported by practically every tropical country in America and Africa, and occasional shipments go even to Asia and the East Indies.

Minor products of the tropic forest. The tropic forest is more important for minor products than for its wood. At one time the world's entire supply of rubber was obtained from the *hevea brasiliensis,* or wild rubber tree of the Amazon forest. The story of the migration of rubber production from the Amazon forest to the plantations of the Far East, and thence into the synthetic rubber factory, has been told in another chapter.

Closely allied to rubber from the botanical standpoint are many other gums that are produced from the dried sap of trees. The well-known "gum arabic" so commonly used as office paste has the useful quality of being soluble in water and is plucked from trees by natives throughout the half-forested belt that lies between the jungle and the desert and reaches across Africa from Senegal to Ethiopia. It is also shipped from Somaliland, India, Australia, and South Africa.

Gums of another class, known as copals, are with difficulty soluble and therefore serve as the basis of varnish. They are produced by many trees. One, the kauri gum of New Zealand, is extratropical, being found in a fossil condition covered by the surface earth where it has dropped from kauri trees of past ages. It has been diligently dug for the last 80 years and is still being found, and small quantities are produced by the living forest. Other copals are dug from the earth in Madagascar, Zanzibar, and adjacent Africa, but the greatest center of shipment for these gums is Singapore, the Malay metropolis. Here also is gathered for shipment a large proportion of the world's rattan, the jointed stem of a creeping vine that runs for hundreds of feet through the tropic treetops and helps bind them together in the jungle mass. Properly split, it makes the cane seats of chairs.

Nuts make an entirely different class of forest product and one of indefinite expansion. From Pará, Brazil, come the dark Brazil nuts with their triangle cross section and rich white meat, said to contain one of the four perfect proteins. They could apparently be produced (picked up) in indefinite quantities if desired.

The tagua nut (vegetable ivory) is sometimes as large as a hen's egg. It is obtained from a palm tree that may live for 100 years and that yields as much as 30 pounds of nuts annually. Ecuador exports 10 to 15 thousand tons of tagua nuts a year to Europe and the United States for use in button manufacture.

The babassú palm of the Amazon forest is prolific, a single cluster containing as many as 400 nuts. These nuts are used in making soap and margarine. Brazil ships 15 to 30 thousand tons of babassú nuts annually to Europe and the United States.

Chicle, the basic raw material in chewing gum, is obtained from the sap of the sapodilla tree in the forests of the Yucatan Peninsula of Mexico and British Honduras. The United States imports about 3000 tons of Mexican chicle and about 500 tons of chicle from British Honduras annually. Philip K. Wrigley, the chewing gum manufacturer, has estimated that in a single year the American public

chomped 19 billion sticks of chewing gum, or enough to encircle the Equator $34\frac{1}{2}$ times (prior to mastication, no doubt).[17]

8. NAVAL STORES

Principal uses. Rosin is the gummy substance remaining after turpentine has been distilled from the sap of longleaf and slash pine trees. Because tar and pitch obtained from pine trees were long used to calk seams of wooden ships, rosin and turpentine acquired the name "naval stores." Although wooden boats are calked with rosin and turpentine, this is a minor use today. Rosin has long been used to improve the lathering power of yellow laundry soap. Both rosin and turpentine are used extensively in the paint, varnish, and lacquer industry, and small amounts are used in the manufacture of medicine.

The production of naval stores. More than half of the world's naval stores are produced in the longleaf and slash pine forests of the southeastern United States. The production of naval stores, as formerly carried on in the American South, was very injurious to the forests. The sap gatherer made great wounds in the base of the tree from which in a few years it bled to death. During the process it was exposed to easy destruction by fire and was easily overturned by windstorms. This wasteful practice has been replaced by a newer way of turpentining, known as the cup-and-gutter method, which does not gash the tree so deeply and greatly prolongs its life and yield.

Today much sap is also recovered from old pine tree stumps. Inasmuch as the slabs that are burned or wasted around many southern sawmills also contain large quantities of sap, as do the small branches and tops that are left in the woods, it is likely that the near future will see more economic methods of gathering naval stores. Some processes now in use take all this refuse wood, soak the sap from it for distillation, and leave the pulp thus purified for making paper.

The French gather turpentine much more effectively than we do. They use the method which our Forest Service is requiring in the national forests—"turpentine thinning." This means gradually bleeding to death the trees it is desired to remove, thus serving a dual purpose by using the wood of the exhausted tree. Such trees from France prop many a British mine, while the thinning promotes the growth into sawlogs of the trees that remain.

The most recent development is the recovery of naval stores as a by-product of pulp manufacture. This efficient process now accounts for nearly one half of all rosin and turpentine produced in this country.

9. WOOD MANUFACTURES

Rough and finished lumber. The manufacture of the heavy log into rough lumber naturally clings to the forest, although special conditions cause some export of logs, especially of such high quality woods as mahogany and walnut, which may be used for veneers. The further manufacture of lumber—usually carried on in planing mills where the rough boards are finished—tends to concentrate near the market in or near centers where building operations are largely carried on. This is only logical since the rough lumber is more readily moved and stored than the easily injured dressed plank or the sash, doors, blinds, and special shapes that the planing mill turns out for the builder. For some years there has been a growing tendency to attach the planing mill to the sawmill. Slabs and small pieces can be made into sash and other things using small pieces.

Furniture. The same factors tend to locate furniture manufacture in great centers of consumption, especially in timber-importing countries. Thus London is both market for product and center for raw material because the imported wood is unloaded there from the ships. Likewise, New York is important.

Owing to an early start when nearby timber supplies were abundant, and since then to very low freight rates, we have had a furniture industry developed near the former area of wood supply in Grand Rapids and other towns

[17] "Americana," *Time,* August 30, 1948, p. 20.

in Michigan, Illinois, and Indiana. Today North Carolina leads in furniture manufacture, with High Point as the major center.

The modern furniture factory in Grand Rapids, High Point, or elsewhere uses quantity-production methods similar to those in use in the Ford automobile plant. Handwork is at a minimum, and machinery does every possible part of the cutting, shaping, and assembling of parts. You may see 10,000 tables going through the factory at the same time, and all identical in wood, design, finish, and workmanship.

The "knock-down" system of furniture making, which has been extended to boats and even houses, has helped many such cities to maintain their wood-working industry even after the nearby timber supply has been exhausted. The expense of importing the raw lumber is balanced by the saving in freight. Furniture is expensive to ship, not so much because of its weight, but because of its bulk. "Knock-down" furniture can be taken to pieces, permitting economy of space in shipping. In this way the parts of boxes and barrels (called shooks) are shipped ready to put up.

The constantly increasing price of hardwood lumber used for making furniture, fixtures, and cabinets has caused the substitution of much built-up lumber, usually made of three-ply veneer. Veneer is wood sliced into thin sheets like pasteboard or even like paper. Thus a fine hardwood log selected for beauty of grain can be used as the exterior finish for thousands of articles of furniture made of cheaper wood. In manufacturing this built-up material it is possible to utilize woods that heretofore have been practically valueless, owing to their tendency to twist and warp when sawed into lumber. The large increase in the manufacture of veneer and its use for cheap industrial purposes is suggestive of the advancing economy of wood that scarcity and high prices are forcing upon us.

At Laurel, Miss., a plant uses another process. Wood is chipped, put into a cylinder for a short time with steam at 1200 pounds pressure. Upon release of pressure the chips explode. The fibrous soupy mass is immediately pressed into boards of any desired dimensions. The naturally adhesive lignin of the wood makes this new wood stronger than the old.

10. THE MANUFACTURE OF PAPER

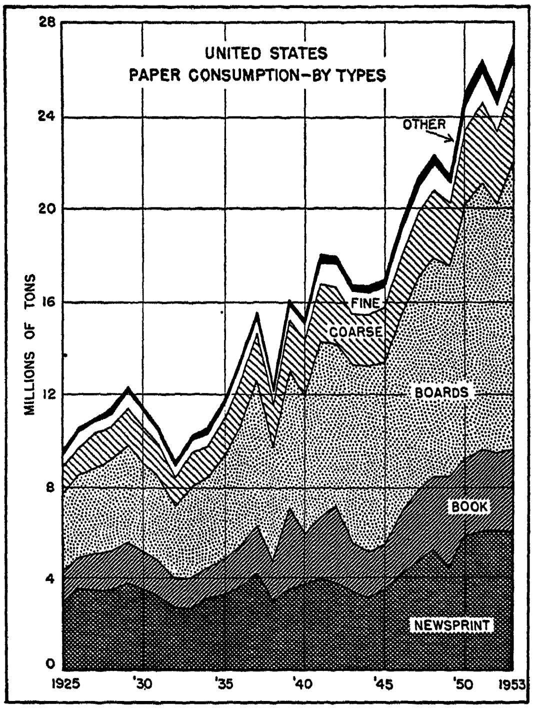
Changes in raw materials. Some material for the easy recording of thought is important in civilization. It is one of the necessary bases of an elaborate culture. The inhabitants of Babylon, Nineveh, and other cities of Mesopotamia wrote on clay tablets and baked them, making the clumsiest but most enduring of all books. The Egyptians used papyrus, a writing material made of stalks of a sedge thinly sliced, lapped together, and pressed into sheets. Together with parchment made of sheepskin, papyrus continued to serve the needs of man until after the fall of Rome.

Paper was first invented by wasps and hornets, who still maintain the industry and defend the product. They use the same process now followed by man—macerating wet vegetable fiber and spreading it out thin to dry.

The art of paper making was discovered in A.D. 105 by Tsai Lun, a Chinese, who found that rags were the most satisfactory material. The art spread through Central Asia and into the Arab world, being introduced into Europe about A.D. 900. Paper mills were in operation in Spain and Italy in 1150, in France in 1189, in Germany in 1291, and in England in 1330. From the time of Tsai Lun until the middle of the nineteenth century, rags remained the chief paper-making material. Linen and cotton rags are today the best of all materials for the manufacture of durable, high-grade writing and book paper.[18]

The use of wood pulp in conjunction with rags began in Germany in 1840, and the manufacture of cheap paper entirely from wood pulp got under way in the United States

[18] *The New York Times* sells to libraries an expensive "rag edition" which, because of its durability, can be preserved as a record for posterity.



Like so many other materials, paper increases faster than population. Carton replaces store box, and paper some textile bags.

in the 1880's. Throughout the present century most of the world's paper has been made from wood pulp. In this country wood pulp comprises about 60% of all raw materials used in paper manufacture, and about 70% of all pulpwood is obtained from spruce, yellow pine, and hemlock trees. Fortunately, paper can be reprocessed, and about one third of all paper made in this country is made of waste paper, which is used primarily in the production of paperboard.

Nearly all plants have cellulose fibers in them. As indefinite numbers of vegetable materials will make paper, the actual choice of materials depends upon their relative quality and cost. During the latter half of the nineteenth century much paper in England was made of esparto grass, imported from North Africa and Spain.

Exceptionally strong paper bags are now made from the jute of discarded burlap and manila hemp of old rope. The fine paper used for bank notes is made from the bark of the baobab tree, a material containing long and strong fibers. Cheap wrapping paper and pasteboard are made of straw. In 1953 the first newsprint-from-bagasse plant was established at Lockport, La., this plant using the crushed cane stalk that is left when raw sugar is extracted from sugar cane.[19]

The manufacture of paper from wood pulp. To convert wood into pulp, short logs may be ground into mush by huge power-driven grinding stones or the logs may be cut into chips which are cooked in chemical solutions that eliminate all woody substances but the cellulose fibers, the chief basis for paper manufacture. The fibers float in water that is kept at a uniform soupy thickness by stirring. For centuries paper making was a handicraft carried on by the paper maker and his family, who dipped sieves into vats of floating fiber and carefully lifted out upon the wire gauze enough fiber to produce a sheet of paper when properly dried. Now, continuous-process machines turn out more than 500 feet per minute and send it away from the factory in sheets often miles in length wound upon spools into rolls 3 or 4 feet in diameter.

If the paper is to be used for writing purposes, the spaces between the fibers are closed by a process called sizing, which fills up the pores with material chiefly composed of china-clay, rosin, alum, or talc, a process that greatly adds to the weight of the paper. While the expensive hand method of paper making prevailed, the price was high, and demand for paper was small. The discovery of wood pulp and the invention of machines to turn out paper in quantity have made it cheap enough for a wide variety of uses (see Fig. 500).

Location of paper manufacturing. Before the pulp era, our paper mills, like our woolen mills, had been clustered along small streams in the vicinity of centers of population. The great increase in the use of wood

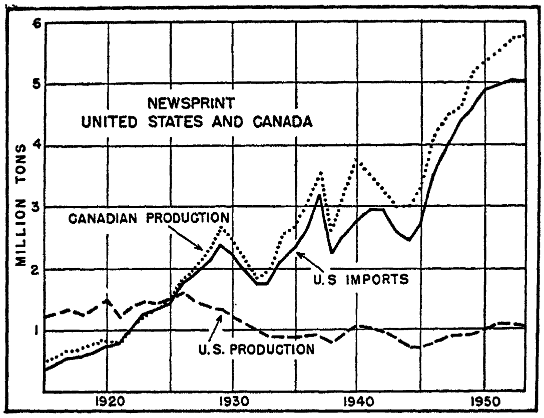
[19] "Bagasse-Type Newsprint to Be Produced," The New York *Herald-Tribune,* Section 2, March 15, 1953, p. 7.

pulp for paper in the United States since 1890 caused the transfer of the center of the paper industry away from the market to the forest districts. Fully two thirds of the pulp mills of this country use hydroelectric power, because, when available, it is the cheapest source for the great amount of energy required to grind the wood into pulp. Relatively pure water is also a very important consideration, because the dirt of the water can adhere to the floating fibers and thus pass into the paper.

For some years the production of wood pulp was concentrated in northern New England and New York, but the industry soon became established in the Lake states and later in the South and the Pacific Northwest. Washington, Florida, and Louisiana lead in wood-pulp production with about one third of the nation's output. Since 1930 many new pulp and paper mills have been established in the South, which now accounts for about one half of all wood pulp and more than one third of all paper manufactured in the United States. About four fifths of all paper in the United States is made of chemical wood pulp.[20]

Raw materials, power, market, and the impetus of an early start are major factors that together determine the location of paper manufacturing. While the production of cheaper grades of paper has shown a definite tendency to follow the lumber industry into the South and Pacific Northwest, the location of book paper and writing paper has been little affected by the new and cheaper sources of wood.[21]

High-grade writing and book papers are made of chemical wood pulp, chiefly spruce and aspen (poplar), to which rags have been added to give a superior finish. Spruce and



The power of the press. The fact that every newspaper in the land uses newsprint and can raise a howl—and does so, loudly—has made it impossible for the paper manufacturers to get away with a protective tariff. *American Paper and Pulp Association*

aspen are northern trees, and rags are most plentiful in the more densely populated states. Pennsylvania, Massachusetts, and Ohio lead in the manufacture of book paper, while Wisconsin, Massachusetts, and Pennsylvania lead in writing paper.

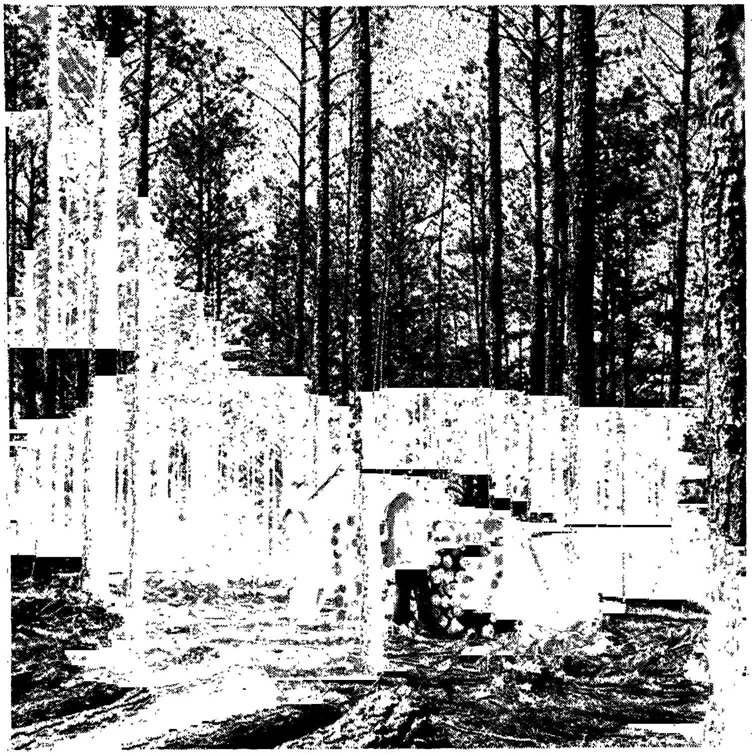
The South is predominant in the manufacture of kraft paper, which is made chiefly of yellow pine pulp and is now commonly used in the manufacture of tough brown wrapping paper and bags.[22] Michigan, Ohio, and Louisiana lead in the production of paperboard, which can be made at about equal cost from wood pulp, waste paper, or straw. The South leads in the manufacture of kraft board, the Middle West leads in strawboard, and the production of chip board from waste paper occurs in or near big cities where waste paper is most abundant.

Nearly 60% of all newsprint in this country is produced in Maine, while Washington,

[20] The sulfite process, employing a cooking solution of calcium bisulfide, is used to make pulp from such long-fibered and nonresinous woods as spruce, hemlock, and fir. Most wood pulp in this country is now made by the newer sulfate process, which can be used for both resinous and nonresinous woods. The sulfate process employs a mixture of caustic soda and sodium sulfide; the cooking takes more time, but much of the solution can be reclaimed and reused.

[21] See John A. Guthrie, *The Economics of Pulp and Paper.* The State College of Washington Press, Pullman, Wash., 1950, pp. 3–6 and 36.

[22] The world's largest kraft-paper plant, owned by the Union Bag & Paper Corp. at Savannah, Ga., needs 5000 employees to process 200 carloads of southern pine every day into 1800 tons of kraft paper, 35 million paper bags, and 300 tons of corrugated boxes. Advertisement, Remington Rand, *Time,* February 15, 1954, p. 101.




(*Left*) Properly managed South Carolina forest: loblolly pine. Forty years old, first cutting was 1828 board feet lumber, 14 cords pulp wood, 22 cords left standing on each acre. Next cutting in 7 years. Such a forest might have been producing naval stores. *American Forest Products Industries.* (*Right*) Nursery and one of 12 million little pine trees—Florida. This need not happen if lumbermen leave seed trees. *St. Regis Paper Co.*

Oregon, Texas, and Alabama account for most of the remainder. About 70% to 80% of all newsprint is made from groundwood or mechanical pulp. Newsprint is now being made at Calhoun, Tenn., Lufkin, Tex., and Childersburg, Ala., from the pulp of loblolly and slash pine trees, inferior but rapidly growing species that cover much of the cut-over forest land in the South. Domestic production of newsprint, however, is woefully inadequate to meet the voracious demands of our newspapers. More than 80% of all newsprint used in this country must be imported, and nearly all of it comes from Canada (see Fig. 501).

Development of scientific forestry. The manufacture of pulp and paper is a hog for electric power, and the large self-contained mill, producing both pulp and paper, usually manufactures its own power or is closely associated with a power company. A mill with its turbines and heavy machinery is expensive, and the great cost or impossibility of moving it makes it necessary that a paper company shall be sure of its wood supply. To do this a paper company must often own the land, and it cannot flit from tract to tract after the manner of sawmills. Some of the paper companies owning large areas of spruce land became the earliest large timber owners in the United States to protect their forests and cut them rationally—forestry. As their enterprises are often located in the deep forest, the companies must sometimes even build and own the towns in which the people live who make their paper.

A good example of this is afforded by the town of Millinocket, Maine, where a huge pulp and paper mill was located far in the forest beside a great waterfall. A special railroad was extended to it, and the town built around the mill. The original plant cost $25 million—an excellent evidence of the impossibility of moving and of the consequent neces-

sity for conservation of wood supply, both by avoiding wasteful cutting and by replanting burnt-over lands, but above all by stopping fires. This company now owns plants at Millinocket, East Millinocket, and Madison, with an aggregate capacity of 1000 tons of pulp per day, and it owns or controls about 2 million acres of forest land which is so well managed that it can yield pulp wood for an indefinite time.

The great International Paper Co. owns stumpage rights to over 35,000 square miles of forest land. This goliath of the paper industry has 35 mills scattered from Ontario to Florida and from Newfoundland to Wisconsin.

The position of the United States. In 1950 the world produced 47 million tons of paper. About 85% was produced by seven nations—the United States, Canada, Great Britain, West Germany, France, the Soviet Union, and Sweden.[23]

The United States ranks high in the world's paper economy (see Table 28:1). In 1950 this country produced about 43% of the world's wood pulp, and it manufactured 52% of the paper. However, it produced only 10% of the newsprint, as compared with 58% for Canada and 32% for the rest of the world. U. S. paper imports, chiefly newsprint, amounted to 60% of the world's total imports. In 1953 the United States purchased $632 million worth of foreign paper and $263 million worth of foreign wood pulp.

No other people in the world use so much paper as do the people of the United States with their large consumption of newspapers, magazines, books, wrapping paper, boxes, cartons, tissues, and other products. Between 1899 and 1953 our consumption of paper increased from 58 to 391 pounds per capita. About 65% of the world's paper is consumed in the United States.

The paper industry in Europe. Great Britain, one of the important paper-manufacturing countries, derives all her wood pulp from foreign lands, principally from three Scandinavian countries. Most of the other European countries manufacture paper, and many of them export it. Germany, located in the center of Europe where millions of people are daily converting clothing into rags, draws on the best raw-material supply in the world for the manufacture of fine rag paper, and sends her paper products all over the world.

TABLE 28:1. The Position of 20 Selected Countries in the World's Paper Economy, 1950

Country	Production	Net exports (+) or imports (−)	Per-capita consumption
	Thousands of short tons		Pounds
United States	24,300	4,635−	382
Canada	6,812	5,009+	260
Great Britain	2,928	447−	133
Denmark	115	165−	131
New Zealand	45	77−	124
Iceland	0	8−	110
Netherlands	696	153+	108
Norway	530	356+	107
Switzerland	242	5−	105
Sweden	1,301	956+	101
Finland	864	664+	99
Belgium	328	80−	94
Germany, West	1,725	40−	73
Australia	193	67−	64
France	1,451	128−	63
Argentina	171	215−	45
Japan	966	21+	23
U.S.S.R.	1,313	a	14
China	209	a	2
India	122	104−	1

a Not available.

Source: Computed from American Paper and Pulp Association, *Operating and Financial Statistics, Special Statistical Studies No. 1,* report to paper and pulp manufacturers, New York, February 21, 1952.

In the production of wood pulp for paper the Scandinavian countries are in a position to supply the needs of all Europe and even ship some to the paper-hungry United States. Sweden, with her large percentage of forests for raw material and mountain streams for

[23] American Paper and Pulp Association, *Operating and Financial Statistics, Special Statistical Studies No. 1,* report to paper and pulp manufacturers, New York, February 21, 1952. According to another estimate, the world's production of newsprint (excluding the U. S. S. R.) amounted to 8.6 million metric tons in 1950 and 9.3 millions in 1952, while the world's output of other paper (excluding the U. S. S. R. and China) amounted to 18.6 million metric tons in 1950 and 19 millions in 1952. United Nations, *Statistical Yearbook, 1953,* New York, 1953, pp. 201–202.

water power, exported pulp and paper valued at $372 million in 1953. Norway, with similar resources, had an export of $186 million, and Finland's share was $212 million. In all three countries wood in the form of paper and pulp was the leading export.

Paper in Latin America. The per-capita consumption of paper in Latin America ranges from less than 2 pounds in Bolivia and Paraguay to about 45 pounds in progressive Uruguay and Argentina. Approximately 86% of all paper manufacture occurs in Brazil, Argentina, Mexico, and Chile—the region's industrial leaders. Paper mills in Brazil provide about 80% of the nation's paper supply; in Chile and Mexico, over 70%; and in Argentina, about 50%. All four of these countries are importers of newsprint and wood pulp.[24] Latin America imports 88% of its newsprint.

At present the temperate forests of southern Brazil and southern Chile are the most accessible and prolific sources of wood pulp, yet Brazil imports almost half of her chemical pulp supply, and Chile about 80%. Tropic and subtropic forests comprise about 95% of Latin America's forest area. Recent experiments indicate that both mechanical and chemical pulp can be produced economically from the mixed hardwoods of tropic lands, although further research is needed to perfect manufacturing processes. A number of paper mills using sugar-cane bagasse are already in operation. The tropic forests and cane fields of Latin America may eventually make a major contribution to the world's paper supply.

Paper in China and Japan. The Chinese first invented paper and still make an excellent quality. The cheap paper is made of rice straw, while the so-called fine "rice" paper of commerce is made from the pith of a plant grown in Formosa.

It is in Japan that we see paper rendering its greatest and most varied service. With a small arable area, the Japanese are compelled to make paper fill uses supplied in other countries by the products of agriculture. Thick, tough papers are substitutes for leathers, which they cannot produce at home owing to their lack of cattle. A very strong and durable paper is made from seaweed; and the Udo, a bush, also called paper mulberry or paper plant, is grown on many Japanese hillsides for the very strong paper that can be made from its bark and used for grain sacks, for waterproof tarpaulins, and even for walls of houses. Paper is an excellent nonconductor of heat, and the native Japanese house, adjusted to the needs of a country that is often visited by earthquakes, is made earthquake-proof by having a bamboo framework and paper walls. The Japanese paper umbrella and lantern are well known among us, and the Japanese have long used paper napkins and paper pocket handkerchiefs.

In Japan there are two separate and distinct paper industries: (1) the production of tough, pliable, native-style papers, including paper for brush writing, and (2) the manufacture of foreign-style paper. The production of native-style paper, amounting to about 100,000 tons a year, is largely a household industry, employing traditional handicraft methods introduced from China centuries ago. On the other hand, the manufacture of foreign-style paper, amounting to about 1 million tons a year, is conducted in modern mills, using machinery and methods imported from the United States and Europe, and by far the greater part of the output is newsprint. The great bulk of all foreign-style paper is made of wood pulp, as only about 1000 tons of high-grade paper are produced from rags and other fibers.

In 1953 Japanese paper manufacturers imported nearly $23 million worth of wood pulp to augment the domestic supply, which is obtained from the coniferous forests of the northern island of Hokkaido. As in Scandinavia, Canada, and the United States, the modern production of pulp and paper in Japan is well endowed with water power. Japan accounts for one half of all paper consumed in the Orient—hallmark of literacy and progress.

[24] American Paper and Pulp Association, *op. cit.*, and "Paper and Pulp," *Latin-American Business Highlights,* The Chase National Bank, New York, June 1954, pp. 9–12.

29· Vegetable, Animal, and Man-made Fibers

Fibers for clothing and for household and industrial uses are the product of wide-reaching world industries, which, with the production of their raw materials, touch all countries in varying degrees. A large number of animal, vegetable, and man-made fibers contribute and compete, but more cotton is produced than all the others combined. In 1953 the United States consumed three times as much cotton as man-made fibers, whose rapid rise has displaced wool from second place in recent years. Because of its commanding position in cotton growing and in synthetic fiber production, the United States is the major factor in the world's supply of fiber raw material.

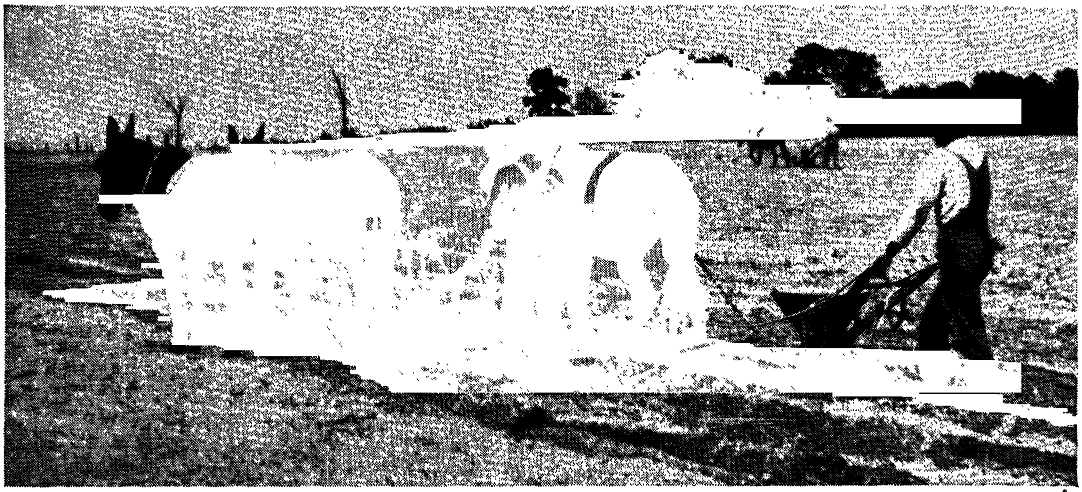
1. THE SUPPLY OF RAW COTTON

The universal use of cotton. It is probable that few readers of this book ever saw a person in whose clothing cotton did not play some part, for it is alike a fabric for clothes of high fashion, for those of everyday use, as well as for the breech cloth of primitive peoples.

Cotton was in extensive and general use in India more than 3000 years ago. Unlike most other important plants, its distribution throughout the part of the world suited to it took place at a very early time, probably by natural means. Nevertheless, until the end of the eighteenth century cotton was one of the most expensive fibers, because hand labor was the only method of separating the fiber from the seed. A day of careful, slow work was required to separate the seeds from 1 or 2 pounds of cotton, and this made cotton more expensive than wool and linen.[1]

An agricultural revolution resulted from Eli Whitney's invention of the cotton gin in 1793. The cotton gin separates the seeds by a very simple mechanical device, in which slowly revolving sawteeth pull the fibers slowly through a comb leaving the seeds behind. This saving in labor changed cotton from a luxury to a necessity. The gin and tillage machinery promptly transferred it from the class of garden and hand-labor crops to the class of field crops, from areas of cheap labor to areas of cheap land, from the populous West Indies and parts of Brazil to the broad fields of the almost empty southern United States. Our production rose from 4000 bales in 1791 to 10

[1] At the beginning of the nineteenth century only 4% of all fabric produced was from cotton, 74% from wool, and 18% from flax (linen). A century later the figures were 78% from cotton, 20% from wool, and 6% from flax. W. S. Woytinsky and E. S. Woytinsky, *World Population and Production—Trends and Outlook,* Twentieth Century Fund, 1953, p. 600.



Old style. Man at left makes planting furrow for 2 rows; second man sows fertilizer; man in the distance plants seed. Now one man with a tractor does it all. ***Texas Agricultural Extension Station***

million bales a century later.[2] This agricultural revolution, together with the revolutionary developments of textile machinery, enabled a great manufacturing industry to spring up—first in England and the United States, later in other parts of the world.

Cotton retains its dominance in world fiber markets for two basic reasons. (1) It can be grown in large quantities, in many areas, at relatively low costs. (2) It has an excellent combination of properties that makes it suitable for a wide range of uses, in contrast to the more or less specialized "end-uses" for other fibers.[3]

Natural cotton regions. Cotton is a woolly fiber attached to the seeds of a shrubby plant and contained in a pod or boll, which at ripening time opens so that the white fiber protrudes in a mass about the size of a small apple. Naturally tropical and subtropical, the plant will grow almost everywhere throughout the world between 40°N. Lat. and 30°S. Lat. The poleward extension of cotton growing is limited by the requirement of about seven months of frost-free weather. However, like many other useful plants, cotton tends to be more productive toward its northern limit. The unmitigated heat and moisture of some tropic locations cause the plant to flourish for years. But the gradual cooling of the early autumn or the approach of a dry season in other localities suggests death to the plant and drives it to seed and fiber production and higher yields.

Cotton is less particular in its moisture requirements. It needs a good summer rainfall without too great an excess (especially during the ripening period) and much bright sunshine. These requirements can be met in a variety of climate regions: in west Texas with less than 25 inches of rain a year as well as in southern Mississippi with over 60 inches; in the mild, continental climate of China's Yellow River Plain as well as the Tropical Savanna of the Indian Peninsula and the uplands of tropical Africa and Brazil. Under irrigation cotton flourishes in the dry Mediterranean climate of California and the deserts of Central Asia, Egypt, and Peru (see colored map at front).

Important cotton-producing regions occupy only a small portion of the world area that is climatically suitable for the plant. Within these regions most of the world's commercial cotton is grown on land that is distinctly better than

[2] At the beginning of this period about three fourths of England's import of cotton had come from the West Indies and much of the remainder from coastal areas in Brazil. At the end, the United States supplied three fourths of the much larger world export. And now Fig. 511 shows a change.

[3] See R. E. Evans, "The Utilization of American Cotton," USDA, *Yearbook of Agriculture, 1950–51,* pp. 377–386.

average in terms of soil fertility and flatness. Competition of other crops is a further limiting factor. In densely populated China, India, and Egypt food crops come first. In the United States other commercial crops and livestock increasingly compete with cotton for the use of the land. Finally, shortage of labor or inaccessibility are limiting factors in certain areas.

As with all commercial crops, the actual geography of cotton production results from a complex interaction of influences: environmental, social, economic, and political. These differ from place to place and change with the passage of time.

"Chopping cotton," removing extra plants and weeds—millions of days' work at low wage until the U. S. supported price. *Texas Agricultural Extension Station*

Method of growing and mechanization. Like other fiber crops the production of cotton requires much more labor than most food crops. This is owing to the relatively high value of cotton per acre in comparison to most other major crops as well as to the difficult technical problems of mechanization, especially in picking the cotton.[4]

The cotton seeds, about the size of a small pea, are planted thickly in rows from February to May, depending upon latitude. As soon as the plants are established, they are thinned (usually with hoes), after which frequent cultivations with the hoe, plow, or cultivator are needed to keep down the weeds. These processes, particularly thinning and cultivation, constitute the first of two major peaks in seasonal labor requirements. Later in the growing season the plant attains a height of from 2 to 5 feet, produces a beautiful blossom followed by a green pod, which later bursts open, showing the bunch of white fiber.

Harvest time brings the second peak in labor demand. Most of the world's cotton is picked by hand, although the effort to develop a machine harvester goes back at least a century. It has proved difficult for a machine to equal the efficiency of the human fingers in removing cotton fiber from the open boll—all of it and cleanly, without excessive leaves and trash. Then, too, all bolls do not ripen at the same time so that the field must be picked over several times before the crop is harvested.

In addition to the complex technical problems other factors have hindered the development of a successful picker, even in the United States. Among them are the small size of many cotton farms, the hilly terrain in important producing areas, systems of land tenure, and the heavy early-season labor requirement, which reduces the benefits to be gained from mechanization of harvest operations. This last hindrance has been much modified in the United States during the last 25 years. The use of tractors with improved plows, seeders, and cultivators has so greatly reduced the early-season labor requirements that a 1948 experiment in the Mississippi Delta showed that "for cotton produced under 'usual' mechanization practices, the handpicking operation

[4] In the United States the 1952 cotton crop from 25 million acres was about equal in value to the wheat crop from 70 million acres but required 7 times as many man-hours to produce. Thus it took an average of 76 man-hours to produce an acre of cotton but only 4 man-hours for an acre of wheat and 14 for corn.

(Above) **Picking cotton, old way. Tenant houses in background.** ***Texas Agricultural Extension Service. (Below)*** **See how this monster from a Corn Belt factory strips the cotton and makes the Negro migrate.** ***John Deere***

accounted for 85% of the labor required."[5] In such a situation the mechanical picker is not only more feasible but it also becomes the chief means of further reduction in costs of cotton production.[6]

Two general types of mechanical harvester are in commercial use today. The tractor-mounted stripper removes the entire boll, leaving only the stalk and heavier branches. The spindle picker is a separate machine, usually self-propelled and more expensive than the stripper, which removes cotton from the bolls by means of moistened, revolving spindles. The widespread use of mechanical harvesters depends on many related innovations —the development of cotton varieties suitable to the machine, new techniques of planting and spacing, chemicals and flame weeders for weed control, the use of chemicals to defoliate the mature plants, and modification of ginning techniques to handle cotton with more trash.

Progress along these various lines has been rapid in the United States since World War II. Mechanical picking was just beginning in

[5] G. C. Crowe, "Mechanical Cotton Picker Operation in the Yazoo-Mississippi Delta," Mississippi State College, Agricultural Experiment Station, *Bulletin No. 469,* July 1949, p. 3.

[6] In Egypt 1500 man-hours are required to produce 500 pounds of cotton and 208 man-hours are required in southeastern United States with one-row mule-drawn equipment, but only 15 man-hours on the high plains of Texas with complete mechanization. Woytinsky, *op. cit.,* p. 607.

1945 but by 1952 there were 12,000 pickers and 20,000 strippers in operation. The Department of Agriculture estimates that 22% of the nation's crop planted in 1953 was harvested by machine. State percentages ranged from 59 in California to 24 in Texas and 6 or less in the South Atlantic states.[7] We may be in the midst of a revolution in cotton culture as fundamental and widespread in its effects as Eli Whitney's cotton gin.

By-products from cotton. The cotton seed, one of the most nutritious of morsels, was for a long time thrown away or even burned. Later it was returned to the fields as fertilizer. Then came the discoveries that the oil in which it was so rich could be extracted and put to many and rapidly increasing uses. The manufacture of cottonseed oil is now an important industry throughout the South. About 6 million tons of cottonseed are now crushed annually. A ton makes from 36 to 42 gallons of oil. The oil cake which remains after pressure contains about nine times as much of the important plant foods—phosphoric acid and potash—as does the fiber produced by the plant.

It is thus evident that the returning of the seed to the land is an excellent way to maintain soil fertility, but the food value is too great to permit such use. The cheapness and great richness of this cottonseed meal in protein has led to its appreciation as feed for dairy cows, and it is shipped to every important center of butter and cheese production in the United States and Europe.

For the use of cottonseed oil in place of butter or lard, see the section on Dairy Substitutes in Chapter 13. There is no good reason why it should not be more widely used to enrich our bread.

2. COTTON IN THE UNITED STATES

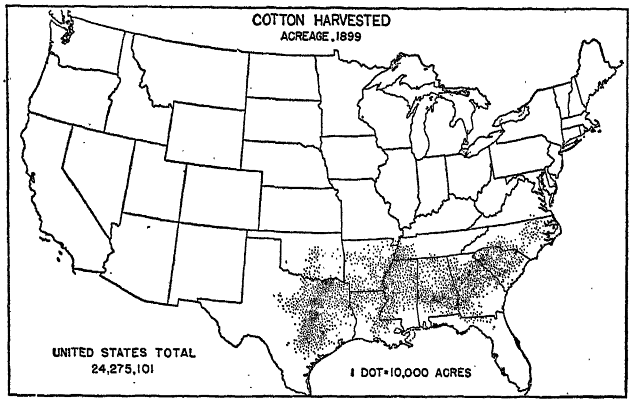
Although our dominance of the cotton world is less than it was 30 years ago, the United States (1949–53) produces and exports nearly a half and consumes about a third of the world's cotton. More people are engaged in the production of cotton than of any other crop. About one third is exported, and it is generally our leading agricultural export.

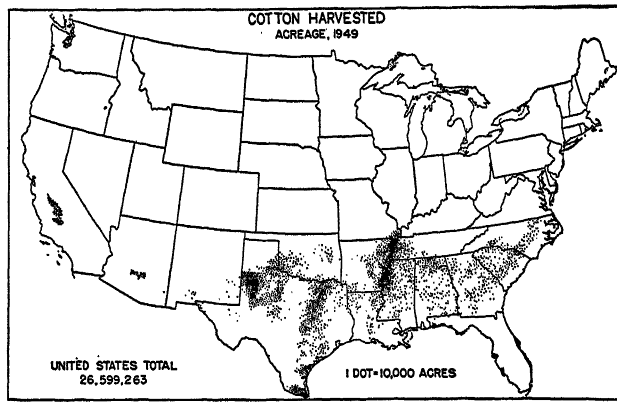
Producing areas in the southeastern states. The term "Cotton Belt" has been applied to a large area from southern Virginia to western Texas, excluding most of Florida but including major parts of Oklahoma, Arkansas, and Tennessee as well as the adjoining corners of Missouri and Kentucky. For over a century this has been the world's leading and most highly specialized cotton-producing area. In no other region has cotton been so important in the economic, social, and political life. The ease with which the grower's cotton—indefinitely keeping, inedible, hard to steal, easily handled, and the king of money crops—could be mortgaged and the great difficulty of mortgaging any other crop were factors in establishment of the great crop-mortgage system in the South both before and after the Civil War. This resulted in emphasis on a single, commercial crop system that for decades was both the chief characteristic and the major agro-economic problem for large areas within the Cotton Belt.

The outer limits of cotton cultivation and the borders of the Cotton Belt are strongly influenced by environmental conditions: the 200-day growing season and rough topography on the north, low and uncertain rainfall on the west, and poorly drained coastal marshland and heavy autumn rainfall along the Gulf and Atlantic coasts. Within this large region, several especially favorable areas have long been prominent on maps of cotton acreage and production (see Figs. 510A and B). In recent decades their prominence has increased, and so today it is more accurate to speak of cotton regions within the Southeast than of a continuous Cotton Belt.

The most important of these in area, yield, and production is the Mississippi alluvial plain with its flood-enriched soil and flat terrain, where cotton occupies about two fifths of the

[7] USDA Agricultural Marketing Service, *Charges for Ginning Cotton, Costs of Selected Services Incident to Marketing, and Related Information, Season 1953–54.* Washington, May 1954.





Compare U. S. cotton acreages. Note new areas: areas of decline and of high density. *U. S. Bureau of the Census*

crop acreage. In Georgia and the Carolinas two old cotton areas on naturally fertile soil continue to produce high yields from substantial acreages: the clay belts of the inner Coastal Plain and the Lower Piedmont separated by a strip of less fertile sand hills. The fourth fertile-soil cotton area is the northern part of the Black Waxy Prairie in eastern Texas. Since World War I a fifth important cotton region has developed on the level High Plains of western Texas and Oklahoma. High yields are obtained where wells provide irrigation water, but much nonirrigated cotton is produced. Large landholdings, flat terrain, and dry harvest periods have encouraged a high degree of mechanization in an area where mechanized grain farming is also practiced.

Smaller areas of concentrated cotton production are found in the lower Rio Grande Valley, the coastal prairies of southern Texas, and the Tennessee River Valley of northern Alabama.[8]

The changing Cotton Belt. Since the middle 1920's, cotton acreage in the Southeast has been cut nearly in half. As a result, much land has been freed for other uses and the "high-density cotton regions" have been greatly contracted in size (see Fig. 510). Cotton production, however, has declined only slightly because yields per acre have increased greatly as the result of improved farming practices, increased use of fertilizer, and the restriction of cotton to the better land. Cotton remains the South's leading crop, but a major diversification has taken place, and farm income from animal products (beef cattle to eggs) greatly exceeds that from cotton in the southeastern states.[9]

This diversification results from a series of influences, the first and most striking of which was the cotton boll weevil. One of the most destructive pests known to agriculture, the weevil lays its eggs in the young bolls, and when the larvae are hatched they feed upon the unopened bolls, causing them to drop off, shrivel up, or rot. Invading Texas from Mexico in 1892, the weevil spread rapidly through the southeast in the decade following 1910. Weevil damage reduced the crop by a third in 1921, a quarter in 1922, and a fifth in 1923, and started a major trend toward diversification.[10]

After the weevil depression of the 1920's came the economic depression of the 1930's

[8] This delimitation of "cotton regions" and also much material in the following section is from the excellent article by Merle C. Prunty, Jr., "Recent Quantitative Changes in the Cotton Regions of the Southeastern States," *Economic Geography,* July 1951, pp. 189–208.

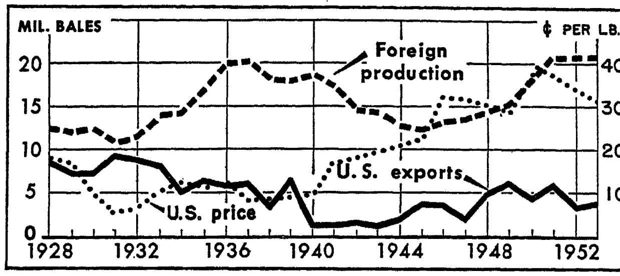
[9] Wilbur Zelinsky, "The Changing South," *Focus,* October 15, 1951.

[10] One of the strangest monuments ever erected is in the little town of Enterprise, Ala. The inscription on it is as follows: "In profound appreciation of the boll weevil and what it has done as the herald of prosperity this monument is erected."

with the limitation of cotton acreage under the AAA. Later the payments to farmers who followed approved land-use procedures under the Soil Conservation Service program, together with education and research by state and federal agencies, further stimulated diversification. Since the beginning of World War II labor shortage and favorable prices for agricultural products have forestalled a reversal of this established trend toward diversification.

Cotton in our southwestern states. The important changes in cotton production in the Southeast have been accompanied by an expansion of production and development of new cotton regions in California, Arizona, and New Mexico. The desert valleys of the lower Colorado Basin in California and Arizona, with their long, dry season and almost continuous sunshine, provide conditions similar to Egypt, where world-famous long-staple cotton is grown. Early experiments with long-staple cotton were successful, and commercial production expanded rapidly in the Southwest after 1912. Meanwhile, the boll weevil had virtually wiped out the production of Sea Island, the best of all cottons, long grown on the low, hot, moist islands along the coasts of Georgia and South Carolina.

Although the Southwest has become our major domestic source of long-staple cotton (50,000 to 80,000 bales a year), the bulk of its expanding output is upland cotton, the chief type produced in the United States.[11] The southern part of California's Central Valley has become the major producing area, and in several recent years California has outranked Mississippi for second place (behind Texas) as a cotton-producing state. The dry climate reduces the danger of the boll weevil. Flat and fertile land, long growing season, and irrigation water are the bases for yields per acre more than twice the national average of 283 pounds.



U. S. cotton price, average upland to farmers. Foreign production rises 12-21. Export sinks 8-4. Significant. Supported price. ***Adapted from U. S. Department of Agriculture chart***

3. FOREIGN COTTON-PRODUCING AREAS

Cotton is produced in about 60 countries, but in 1953 eight countries producing over 1 million bales accounted for nearly 90% of the world's cotton. In addition to the United States, these were India, Pakistan, the Soviet

TABLE 29:1. United States Cotton Production, Southeast and Southwest
(figures in millions)

Average for years beginning August 1	13 Southeastern states[a] Acres harvested	13 Southeastern states[a] Bales produced	3 Southwestern states[b] Acres harvested	3 Southwestern states[b] Bales produced
1925–29	42.1	14.9	.5	.4
1948–52	22.3	12.0	1.8	2.5

a Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia.
b Arizona, California, New Mexico.

[11] The bulk of U. S. upland cotton has a staple (individual fiber) length of from ⅞ to 1⅛ inches. Some 300,000 bales with a staple of 1⅛ inches and longer are competitive with American-Egyptian (mostly above 1⅜ staple) and also with some Egyptian cottons, since about half of Egypt's production has a staple of 1⅛ inches or less.

Union, China, Egypt, Brazil, and Mexico.

India-Pakistan. Asia is second to North America in cotton growing and the Indian subcontinent (India 3.0, Pakistan 1.5 million bales in 1952–53) is second to the United States in production. India has two important cotton-producing areas. One is on the broad alluvial plain around the Gulf of Cambay, where the city of Ahmadabad has become the second largest cotton-manufacturing city on the peninsula. The second and more important cotton area is the plateau at an elevation of 1000 to 2000 feet, east of the Western Ghats in the region commercially tributary to Bombay. Crops depend on the monsoon rains of summer, about 25 to 30 inches per year. The deep, fertile, black soils developed from the Deccan lavas retain the moisture so that the cotton, sown broadcast like wheat after the rains, can mature during the dry season which follows. The postwar food shortage in India caused cotton acreage to be drastically reduced, but it has increased from an average of 11 million acres in 1945–49 to 17 million in 1953.

Most of Pakistan's cotton is irrigated—about 2 million acres in the Punjab and another million along the lower Indus, watered by canals from the great dam at Sukkur. Yields are higher and quality better than Indian cotton.

Partition of the subcontinent has complicated the cotton economy of India and Pakistan. India, with most of the textile industry, is now a net importer of cotton, chiefly from the United States, Egypt, and East Africa. Little comes from Pakistan because of political and currency difficulties. Pakistan usually exports more than 75% of her crop, about half of it going to China and Japan and most of the rest to Europe.

The Chinese cotton belt. Estimates place China's cotton production at between 2.5 and 3 million bales each year from 1951 to 1953[12] —about equal to her prewar production. Much of this is spun and woven by hand in the handicraft production that is still so important in China as well as India. As before the war, imports are necessary to provide the necessary quality and quantity of fiber for the modern textile mills at Shanghai and other port cities.

The climate of central and south China is similar to that of our own Cotton Belt, and much more cotton could be grown were not the land so badly needed for food crops. Important producing areas are in the middle Yangtze Valley around the city of Hankow and also the Yangtze Delta and coastal, saline soils north of Shanghai. In North China cotton is widely grown on the alluvial soils of the Yellow (Hwang-ho) River and its tributary the Wei.

Cotton in the U. S. S. R. By 1950 Russia had regained the prewar production level of about 3.5 million bales, which is more than any other country except the United States but less than India and Pakistan combined. Most of the Russian crop is irrigated, with the major producing districts in the valley oases watered by the melting snows from the high mountains of Russian Central Asia. A second, but much smaller area of irrigated cotton is in the Transcaucasian republic of Azerbaijan along the Kura River which flows eastward into the Caspian Sea. Railroads reached this region and Central Asia in the late nineteenth century and made possible the development of these distant sources of fiber for the textile mills of European Russia.

Since 1928 much effort has been devoted to production of nonirrigated cotton in the Ukraine and other sections of southern European Russia. Cotton growing has been extended to 46° or 47°N. Lat—10° beyond the limit in the United States—into areas with a 130- to 140-day growing season. Although early maturing varieties have been developed, quality is poor and yields are low (90 pounds per acre in prewar years). But despite the high cost of cotton produced under these conditions, the area accounted for one fourth of

[12] U. S. Dept. of Commerce, *Bulletin 190,* "Cotton Production and Distribution, Year Ending July 31, 1953," p. 71. Acreage is estimated at about 10 million —so yields are low.

the Soviet acreage in 1938 and expansion after 1950 increased the acreage beyond the prewar level.[13]

The U. S. S. R. apparently is able to supply considerable cotton to the manufacturing districts in satellite Europe—although the amount is not known.

Egyptian cotton. The Nile Valley of Egypt is without question the best cotton field in the world. The alluvial soil of the Nile Delta, long fertilized by the flood waters, with almost continuous sunshine and warmed by a climate in which there is a steady rise in temperature from spring to summer and a steady decline from summer to autumn, produces about 500 pounds of cotton per acre—nearly double the yield of any other country but below the 627 pounds per irrigated acre in our southwestern states. The 2 million acres planted to cotton is a larger area than for any other Egyptian crop, and represents about a quarter of the cultivated land. This emphasis on cotton raises major problems in view of the rapid increase in population and the need for food imports. Along with other agricultural land, the cotton area is limited by the facilities for irrigation that have been increased since the introduction of modern engineering devices under European management. The greatest of these efforts at cotton extension was the building of the Assuan Dam, which holds back vast quantities of water from the season of flood until the time of need. This permits irrigation at all seasons and has allowed the extension of cotton from the Delta southward along the valley of the Nile during the present century.

The total Egyptian crop is almost 2 million bales a year, and much of it is long-staple cotton of excellent quality, in great demand by the manufacturers of fine cotton goods the world over. From 60% to 80% of Egypt's export goes to Europe, where England, with its fine-goods industry in Lancashire, has always been the leading market. France and Italy are also important. The United States imports less than half as much as it did in the 1920's, and only the better grades, owing to the competition of American-Egyptian as well as the better types of American upland cotton and rayon.

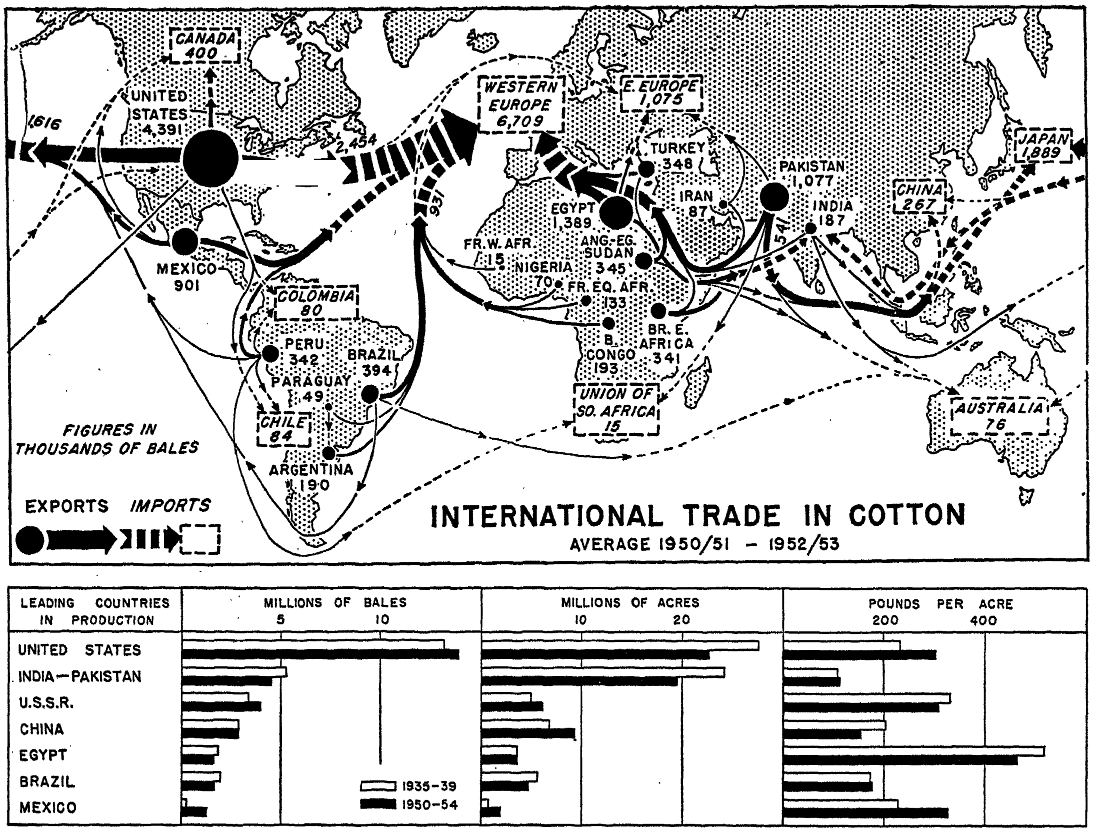
Production of long-staple cotton, developed from Egyptian varieties, has spread with varying degrees of success in other irrigated areas, especially the Sudan, Russia, Peru, and southwestern United States. However, Egypt still supplies three fourths of the premium priced, high quality, long-staple cotton on the world market.

Latin American production. The early explorers found cotton, both wild and cultivated, in various parts of Latin America, and the Portuguese soon developed a significant export from Brazil. Although overshadowed by the nineteenth-century exports from the United States, production in Brazil has expanded, especially since 1930, and now amounts to about 2 million bales a year. Two areas are important. The former sugar lands of northeastern Brazil account for about one quarter of the national crop. Both long, strong-fibered "tree cotton" as well as regular short-staple varieties are grown. The rest of Brazil's cotton comes chiefly from São Paulo, where coffee and cotton vary in acreage and importance according to fluctuations in world prices and demand. Brazil supplies most of the fiber needed by her own textile industry and, at times, has a substantial export.

Cotton production in Mexico has jumped from an average of 330,000 bales in 1935–39 to 1,228,000 in 1950–52. Since domestic consumption is about 300,000 bales there has been a substantial surplus which placed Mexico among the leading exporters in these latter years. Major producing districts are close to the U. S. border on the Colorado River Delta and along the Rio Grande, and also in oases in the dry interior and along the west coast.

Among other Latin American countries, Peru is a regular exporter of high-quality cotton produced in the irrigated areas along

[13] In 1938 Russia produced 3.8 million bales from 5.1 million acres of cotton. Of the total acreage, 65% was in Central Asia, 10% in Transcaucasia, and 25% in the nonirrigated areas of European Russia. See Lazar Volin, "A Survey of Soviet Russian Agriculture," USDA, *Agricultural Monograph No. 5*, Washington, 1951, pp. 133–145.



The map shows newcomers in export. The graph shows that, while the U. S. reduces cotton acres, it still leads. Our irrigated fields in the Southwest do over 600 lbs. per acre. Mexico, Egypt, and U. S. S. R. are also irrigated. ***U. S. Department of Agriculture***

the coast. Northern Argentina, with its mild climate and moderate rainfall, has a large area where cotton can be grown. Production has doubled since 1940 and now amounts to 500,000 bales with substantial export in some years. In the adjacent lowlands of Bolivia and Paraguay conditions are also favorable for cotton.

The United States and the world cotton supply. For nearly 150 years the great dependence of northwestern Europe and East Asia upon the United States for its cotton supply has caused any kind of disturbance of cotton growing or export in the United States to be sharply felt in diverse parts of the world. During the American Civil War, when the northern states blockaded the South and stopped the export of cotton, the price rose to $1 a pound. The resulting "cotton famine" closed mills in Lancashire and other European textile districts and stimulated the export of cotton from Turkey, Egypt, and Brazil. Several times a short production and subsequent speculation in U. S. markets have caused high prices and the shutting down of mills in Europe and Asia.

Since World War II relatively high costs of production in the United States, price supports, and acreage restrictions, as well as the shortage of dollars in importing countries, have interfered with our exports. Only generous loans and outright gifts under various foreign aid programs have made possible the heavy shipments of several postwar years. Such conditions have stimulated production and exports not only in the major producing areas but in a considerable number of other countries (see Table 29:2). The substantial but variable export from such Western Hemisphere countries as Mexico, Brazil, and Ar-

gentina indicates important surplus cotton capacity.

Most of Europe is too far north to grow cotton successfully. However, strenuous efforts have increased European production from an average of 42,000 bales in 1930–34 to about 300,000 in 1951–53. Greece contributes about half the total with most of the remainder from Italy, Spain, Bulgaria, and Rumania.

More significant for world supply have been the efforts of European importing nations to increase production in their colonies and dependent areas. Attention has been increasingly focused on Africa because of its large areas of potential cotton land as well as the loosening of colonial controls in Asia. Production in Africa, excluding Egypt, was only 42,000 bales in 1909 but rose to an average of 555,000 (1930–34) and then more than doubled to 1,546,000 bales in 1953–54. Virtually all this cotton is exported, and in 1953–54 the countries of Africa, excluding Egypt, exported nearly half as much as did the United States. Climate, soil, and labor factors are favorable for cotton in large areas of Anglo-Egyptian Sudan, and British East Africa (particularly Uganda), which together account for about half the production and export (1953–54) in this "Africa ex-Egypt." But Belgian Congo, French Equatorial Africa, and Portuguese Mozambique each produced and exported from 90,000 to 200,000 bales (see Fig. 514).

From this it is clear that the developed and potential cotton areas will continue to offer sharp competition to exports from the United States. Will the further development of mechanization re-establish our old advantage on the world market? Will the competition of synthetic fibers dethrone "King Cotton"? These are questions for your consideration—and for the future.

4. WOOL—THE PREMIUM NATURAL FIBER

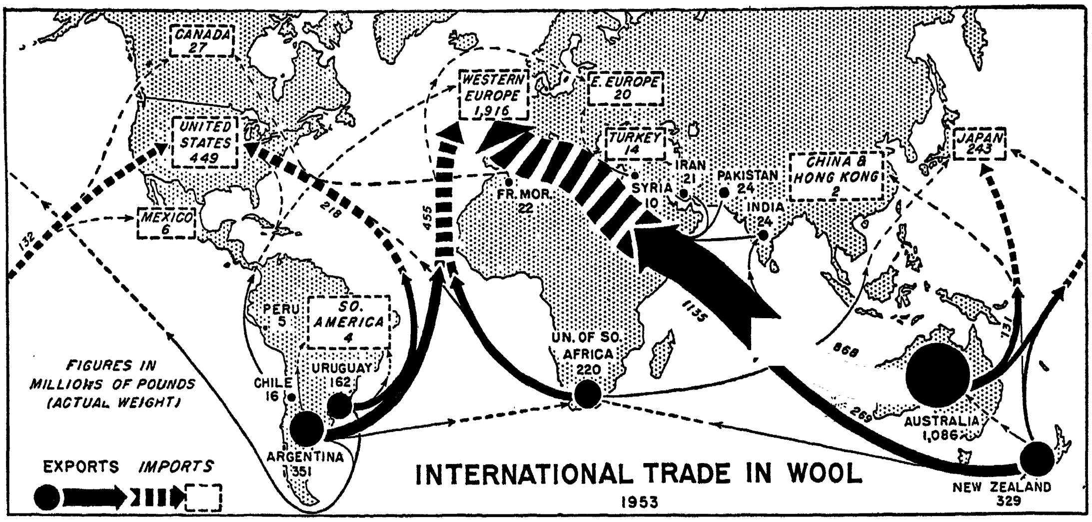
Qualities of wool. Wool holds an ancient and honored place among the fibers. Although far surpassed by cotton in quantity of production and recently overtaken by synthetic fibers, wool continues to command a high price, largely because of its combination of qualities. Wool fiber is crinkly or curled so that the yarn and cloth made from it have elasticity which allows them to hold their shape. The fibers also have minute scales that overlap each other as do shingles on a roof and cause clean wool fibers to cling to each other so that felt, a matted, threadless fabric, can be made by beating and rolling a mass of clean wool. These scales also help to make wool a conductor of heat so that its fabrics have warmth-giving qualities. Finally, wool is more water-repellent than most natural fibers. This combination of qualities—elasticity, felting, warmth, and water-repellence—makes wool highly prized as an apparel fiber, especially among peoples of the cooler climates of Europe and North America.

TABLE 29:2. Cotton Exports, Specified Countries
(thousands of 500-lb. bales)

	1930–34 average	1946–50 average	1953–54 year
United States	7644	4185	3914
India and Pakistan	2440	1311	990
Egypt	1560	1585	1485
Other Africa	369[a]	752[a]	1542
Brazil	234	963	1412
Peru	247	279	361
Argentina	118	77	225
Mexico	20	438	911
Turkey	69	109	377
U. S. S. R.	74	615	1000[b]

a Sudan, Congo, and Uganda.
b Estimated.
Source: Compiled from USDA, *Statistics on Cotton* (Statistical Bulletin #99 and Supplement for 1953), Table 21.
Data for 1953–54 from USDA, FAS, *Foreign Crops and Markets,* Nov. 15, 1954, p. 534.

Production and supply. Because sheep produce both meat and wool, wool production is different from that of cotton and most other vegetable fibers in two important respects. In the first place, it is, in effect, a perennial "crop," since the production cycle extends over several seasons and important increases or decreases in the supply must wait upon changes in the sheep population. Second, much wool is produced as a dual product or even a by-product of mutton and lamb (see Table 29:4), while cultivated vegetable fibers



The Southern Hemisphere—newly settled, sparsely peopled, semiarid—leads. ***U. S. Department of Agriculture***

are "single purpose" even when produced along with other crops. This perennial and dual nature of production means that the supply of wool changes relatively slowly and, consequently, the price of wool fluctuates widely—a situation that creates problems both for the producer and manufacturer of wool.

In Chapter 12 we read that the sheep industry, especially wool production, reaches its greatest importance in grassland areas of relatively sparse population. Although the leading wool producers until the mid-nineteenth century, western Europe and eastern North America are now heavy importers. The world's major supply area has developed in the "wool belt" of the Southern Hemisphere. Five countries—Australia, Argentina, New Zealand, the Union of South Africa, and Uruguay—now account for well over "half the world wool production, three-quarters of the world output of apparel wool, and more than four-fifths of the world wool exports."[14] The United States, fourth largest producer, is a heavy importer (see Table 29:3).

Most of the carpet wool, coarser than the apparel types, comes from the drier sections of the Old World, with production scattered from North Africa and southern Europe to northern India and western China. Argentina and Uruguay, with about a quarter of the world production, are the only significant producers of carpet wool in the Southern Hemisphere.

Transport and marketing. Since raw wool has a relatively high value per pound, it can bear the cost of long-distance transport that sometimes involves long overland journeys. Most wool is shipped "in the grease" arriving at its destination as it came from the sheep's back—a smelly, dirty, greasy mass of fibers. In nature the grease prevents the wool fibers, with their many scales, from forming a mass of felt on the sheep's back. Similarly, clean wool would "felt" during transport unless it were carefully packed. Consequently, the cleaning (scouring) of wool takes place near the wool-manufacturing districts in direct contrast to the cleaning (ginning) of cotton, which is done as close to the cotton fields as possible. This is so despite the fact that the scouring process removes dirt, twigs, and grease which may amount to 75% and averages nearly 50% of the weight of the wool "in the grease."[15] The only by-product from

[14] *Fibers,* U. N., FAO, Commodity Series Bulletin No. 14, 1949, p. 44.

[15] Whether this location pattern results from real economies in transport or the ingrained purchasing habits of the wool trade is a matter of debate. Estimated world output for 1954 is 4.4 billion pounds, greasy basis, which will make 2.55 billion pounds of cleaned wool. This means that nearly one million *tons* of grease and dirt is transported!!

Angora goat, is probably more important than the others combined, and gives some economic importance to "goat country" where little else can be produced (see Chapter 12).

These minor competitors with wool are insignificant in comparison to the great substitutes. Cotton and also "wool-type" synthetic fibers are both much cheaper than wool. While the synthetics do not, as yet, rival wool in all its qualities, both synthetics and cotton are being increasingly mixed with wool and used as substitutes.

TABLE 29:4. World Production of Raw Wool by Major Quality Categories
(thousands of tons)

	1934–38 average	Per-cent	1948–49 average	Per-cent
Merino	645	37	595	34
Crossbred	682	40	741	43
Apparel type	1327	77	1336	77
Carpet type	388	23	388	23
Total	1715	100	1724	100

Source: U. N., FAO, *loc. cit.*

The merino sheep produces the finest wool but almost no mutton. Crossbred wool comes from numerous breeds of sheep with various admixtures of merino blood—the dual-purpose, mutton-wool sheep. One method of wool grading is based on the proportion of merino blood in the various breeds of sheep.

5. SILK—THE FALLEN QUEEN

Silk may be as ancient as cotton, but its function, importance, and geography are vastly different. Primarily a luxury apparel fabric, silk has been highly prized by the more fortunate ladies (and men) since ancient times. Production has always been small in comparison to the more mundane cotton and wool. But its high value has stimulated an important trade in silk from restricted areas of production to the limited, wealthy markets in Europe and North America. More recently man-made fibers have made heavy inroads, and silk is the only apparel fiber whose production has declined during the last two decades.

The silk worm. Hundreds of species of insects spin cocoons in which to pass the chrysalis period of their lives. One of these insects, a moth, commonly spoken of as the silk worm, makes a particularly fine cocoon, the fiber of which we call silk. Each cocoon may contain as much as 4000 yards of this filament extruded by the silk worm, but only a tenth of this may be reeled into the continuous filament yarn known as raw silk. Another tenth may be made into "spun silk" by spinning the shorter and inferior portions of the silk filament into yarn.

The favorite and chief food of the commercial silk~~worm is the leaf of the white mulberry,~~ a tree that will grow in the tropics and in the temperate zones as far as the grape extends, so that natural conditions for silk production are good in much of Europe, a large part of the United States, as well as some large part of every other continent. The successful prosecution of the industry, however, requires a second crop of leaves upon the tree, and this requires a temperature of 54.5°F. for at least three months. Owing to the great amount of labor involved, the distribution of the production of silk depends not upon climatic conditions alone but upon the labor supply, which must be both abundant and highly skilled.

The labor of silk production. The eggs of the adult moth are carefully collected; upon hatching, the voracious young worms are kept in a house upon trays, which must be kept clean through the weeks during which the greedy worm devours his daily portion of fresh mulberry leaves, brought in mostly by women and children. When young, the worms are fed very finely chopped tender leaves five or six times a day and two or three times at night. The worm can endure less cold than the mulberry tree, so the worms are kept in heated rooms in Europe and also in parts of China and Japan. Humidity and temperature must be closely watched or epidemics may carry the worms to a speedy death. When the worms have reached adult size, they crawl into bundles of straw to spin the cocoons (in 24 to 48 hours), which the women pick out by hand.

Preparation of the fiber also requires cheap and adept labor. Steaming or baking kills the worms before they cut through the cocoon,

after which soaking in hot water loosens the fibers so that they may be unwound from the cocoons and reeled. The individual filaments are so fine that four or five are combined in a single thread of raw silk. This silk-reeling process was traditionally a household industry in the silk-producing areas. Nowadays commercial silk is reeled in filatures, small factories where lines of women and girls sit, each with her basin in which 15 or 20 cocoons are constantly supplying the filament for three or four threads of raw silk, winding on as many power-turned reels. Since cocoons are both bulky and perishable, the filatures are located in the midst of the producing areas, where they can also tap the agricultural labor forces. The product, raw silk, is thus essentially an agricultural commodity. This requirement for much cheap, careful, and dextrous labor explains why the many efforts to produce raw silk in the United States have been uniformly unsuccessful.

Raw silk in Japan. The production of silk responds to this labor factor so surely that it has been virtually limited to the Far East and the Mediterranean basin, and within these to areas with dense agrarian populations, low standards of living, as well as favorable climate. The rise and decline of the commercial silk industry in the twentieth century is largely a story of the industry in Japan. Since 1920, and in both phases of this cycle, Japan has produced 50% and usually more than 60% of the world's silk.

Silk is particularly suited to the conditions that prevail in Japan. The monsoon rains of summer give the moisture needed to make the mulberry trees yield abundant growth of leaves. The small proportion (less than a sixth) of the land that can be cultivated in standard style still leaves abundant room on the hillside for the mulberry trees, and the overcrowded population supplies the labor. Careful attention was paid to the breeding of silk worms, the control of silkworm diseases, and the techniques of rearing worms and reeling the filament to achieve high and uniform quality of raw silk. In the early years of this century Japan surpassed its major rivals, China and Italy. In no other country was sericulture so important in the national economy as in Japan during the late 1920's, when 40% of the farm families were engaged in the production of silk worms and raw silk constituted two fifths of the nation's exports.[16]

This activity was geared primarily to the United States market, which absorbed two thirds of the world's exports. Thus the stage was set for the catastrophic collapse of Japanese sericulture which resulted from depression, war, and the more lasting competition of man-made fibers (see Table 29:5). Since 1930 rayon (originally called artificial silk) has been increasingly used in the manufacture of woven goods. Silk received a heavier blow from the wartime development of nylon that, as every lady knows, has virtually displaced silk hosiery.[17] Both these and other artificial fibers compete in the industrial uses of silk, although these have never been of major importance. So raw silk seems destined for a more restricted role in the production of quality apparel and decorative fabrics.

TABLE 29:5. Raw Silk Decline in Japan
(figures in thousands)

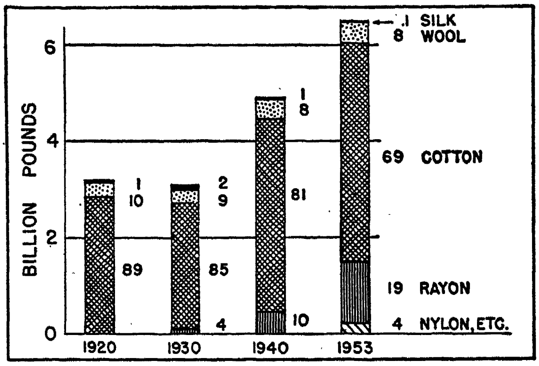
	1934–38 average	1947	1951	1955 (plan)
Mulberry (acres) ..	1413	432	435	613
Machine reeling basins	219	44	48	...
Raw silk production (bales)	721	120	215	305
Export (tons)	30.2	5	4.3	...

Sources: U. N., FAO, *Commodity Reports, Silk,* Rome, March 1953, pp. 5, 7. Exports from U. N., FAO, *Yearbook of Food and Agricultural Statistics, 1952,* Part 2, p. 181.

Other raw-silk producers. These develop-

[16] Glenn T. Trewartha, *Japan, A Physical, Cultural and Regional Geography,* The University of Wisconsin Press, Madison, 1945, pp. 240, 326.

[17] In 1939, 81% of the raw silk consumed in the United States was dedicated to the beautification of milady's legs. This high percentage was partly due to the previous inroads of rayon into other uses of silk. U. N., FAO, *Commodity Reports, Silk,* March 1953, p. 18.



U. S. mill fiber consumption: 25 lbs. per capita in 1920, 36 lbs. 1953. Percentages beside columns. Note changes. What prospective changes? ***Textile Organon, March 1954***

ments have naturally affected other areas (see Table 29:6). Perhaps the greatest silk-producing country is China, although there have never been accurate statistics of either production or consumption. It is a household industry of peasants in many parts of the country but especially in the lower Yangtze Valley, the Szechwan

TABLE 29:6. Raw Silk Output
(tons)

	1924–28 (average)	1934–38 (average)	1951
World	50,900	53,900	21,800
Japan	34,000	42,300	12,920
China	9,000[a]	4,700[a]	3,003[b]
Italy	4,600	2,600	1,220
U. S. S. R.	1,130	500	1,700[b]
All others	2,170	3,800	2,957

a Exports.
b Provisional estimate.
Sources: 1924–28 and 1934–38 averages from W. S. and E. S. Woytinsky, *World Population and Production—Trends and Outlook*, p. 613; 1951 from U. N., FAO, *op. cit.*, p. 4.

Basin, and the area tributary to Canton. These were also the main areas of commercial production. Although China was a poor second to Japan in exports, Shanghai was an important silk market and shipped some of the finest silk in the world. In the 1930's Korea was also a net exporter, while India supplemented a substantial but unrecorded production with imports.

For centuries silk was the mainstay of commerce between the Far East and the Mediterranean world, and the caravan routes across Central Asia have been called "silk roads." According to legend, silk-worm eggs were smuggled over this route and reached Europe in the sixth century. The dry summer of the Mediterranean climate does not favor the mulberry, and so silk production reached major proportions only upon the level, irrigated plains of the Po in northern Italy, where more than three fourths of the European crop is produced. Italy is the only European exporter and sends raw silk to neighboring countries including France, whose small raw-silk production in the Rhone Valley has been totally eclipsed by that of the Po and the Orient.

Other raw-silk localities, some of them quite ancient, are to be found in the Levant, Turkey, and Iran. Most of Russia's production comes from the valleys of the Caucasus Mountains with their mild climate and dense population.

6. MAN-MADE FIBERS

Rayon and acetate. Man's success in duplicating the efforts of the silkworm has resulted in a large and growing synthetic-fiber industry. The varied products of this industry compete not only with silk but also with the other natural fibers and each other. The silkworm makes silk by drawing the fine threads from a jellylike mass of cellulose (called sericin) in its head. This material is made from the cells in the worm's vegetable food, as changed by the chemistry of its body. Man has copied the worm's process. In the rayon industry, solid cellulose from wood pulp or cotton linters is converted into a liquid "spinning solution" similar to the substance from which the caterpillar makes its silk. This liquid is forced under pressure through a thimblelike "spinnerette" with holes as small as 1/500th of an inch. Emerging from these apertures, the liquid is transformed into a solid, continuous filament so fine that it sometimes takes 150 of them twisted together to make a thread. Subsequent processes involve washing, bleaching, drying, and preparing the yarn for shipment. Untwisted rayon filament is also cut into lengths which correspond to the staple lengths of raw cotton, wool, or spun silk. Spun rayon from rayon staple can be woven into

Outdoor factory, Victoria, Texas, shows the bewildering complexity of some manufacture. Distillation columns in which natural gas, butadiene, and other substances go through one process on the way to becoming nylon. Note the man. *Du Pont Co.*

a variety of rayon fabrics or can be mixed with other fibers processed on the machinery of the established branches of the textile industry. World rayon production is about equally divided between continuous filament and rayon staple—in either case the product is a man-made raw material for the textile industries. In the United States, there are

three processes for making rayon, the products being viscose, acetate, and cuprammonium rayon.[18] Viscose is the cheapest to produce and constitutes about two thirds of American production, with acetate making up most of the remainder.

Although these basic production methods had been developed prior to 1900, it required many years of experimentation to overcome difficulties in dyeing and weaving. However, its high luster, versatility, and adaptability for blending and design effects eventually led to widespread use of rayon in the production of broad-woven goods, either as pure rayon fabrics or in combination with wool, silk, or cotton. Some rayon is also used in the knit-goods industry, but much more important has been rayon's invasion of the industrial textile field following the development (in the early 1940's) of high-tenacity rayon yarn suitable for tire fabrics.[19]

The world production of rayon filament and staple has had a striking increase from 4.4 (1902) to 2240 million pounds in 1939, and has since nearly doubled to 4142 million pounds in 1953. Since it is the product of the chemical industry, the leading industrial countries are naturally the major producers. In recent years the United States has produced about 45% of the filament yarn but only about 15% of the staple fiber—roughly a third of the world's combined total. Production in western Europe surpasses that of the United States, with Great Britain, West Germany, Italy, and France the most important individual countries. Prior to World War II Japan was the leading country and is now second to the United States (see Table 29:7).

TABLE 29:7. Production of Man-made Fibers, 1953
(millions of pounds)

	Rayon and Acetate			Noncellulosic
	Filament yarn	Staple	Total	fibers[a]
United States	887	310	1197	301
Japan	163	358	521	15
United Kingdom	207	200	407	20
Germany, West	115	260	375	12
France	103	100	203	13
Italy	117	117	234	8
All other	492	713	1205	16
World total	2084	2058	4142	385

a Includes polyamide fiber (nylon), polyacrylic fiber (Orlon), polyester fiber (Dacron), textile glass fiber, etc.
Source: Textile Organon, June 1954, pp. 84, 86, 90.

In the United States the industry is concentrated in the southeastern states where 12 plants account for almost 70% of the installed capacity—Tennessee and Virginia being the leading states. The Middle Atlantic and Lake states account for most of the remainder, with only 5% of our rayon capacity in New England. This geographic pattern is a response to the rayon industry's locational requirements: access to raw materials, especially supplies of cellulose pulp (90% from wood, 10% from cotton linters), nearness to markets (chiefly

[18] The steps and processes in rayon production mentioned so briefly here are actually complicated chemical operations requiring great care and large investments of capital. A fourth method, the nitrocellulose process, by which the French scientist Chardonnet produced the first "artificial silk" in 1884, has been virtually abandoned because of its high cost. See E. B. Alderfer and H. E. Michl, *Economics of American Industry*, McGraw-Hill Book Co., 1950, Chap. 24.

[19] In 1953 rayon plants in the United States shipped 874 million pounds of rayon yarn. Roughly half went into "tires and related uses," two fifths into broad-woven goods, and the remainder into knit goods and other uses. Figures include viscose, acetate, and cuprammonium rayon filament. Rayon staple fiber shipments were 289 million pounds, 82% of which went to cotton-textile mills.

the textile industries), abundant soft water for processing, continuous electric power, and available labor.

Originally the chief competitor of the silk worm, man-made rayon has become increasingly competitive with both cotton and wool, as its price has decreased and as it has developed qualities comparable to these other fibers. Now rayon straw and rayon horsehair are on the market!

Nylon and other synthetic fibers. In producing rayon, man takes nature's cellulose molecule and adapts it to his own purpose. The nylon molecule, however, is a molecule designed by man to be a fiber—a true synthetic. Before 1930, a chemical research program began to find out why and how small molecules formed the giant ones found in cotton, silk, resin, and rubber. In 1938 a new synthetic fiber was announced which surpassed any known textile fiber in strength and elasticity.

The first step in the manufacture of nylon is the conversion of certain gases and coal-tar fractions. The elements entering into these compounds are carbon (from coal), hydrogen (from water), nitrogen and oxygen (from air), therefore the popular characterization of nylon as a product of coal, air, and water.

Nylon's strength, elasticity, and resistance to moisture made it a military fiber of prime importance for parachute cloth and harness, glider tow ropes, tropical protective covering, and tire cord. Since World War II it has virtually displaced both silk and rayon in the hosiery industry and is increasingly used in dress goods and household fabrics, as well as in industrial uses which depend upon its strength, elasticity, and resistance.

The success of nylon has stimulated the development of other synthetic fibers. In 1945 the Du Pont Co., a leading manufacturer of rayon and the developer of nylon, introduced Orlon, now used in a wide variety of fabrics from awnings to dresses. Dacron, another Du Pont fiber, came into commercial production in 1953.[20] Its wrinkle- and water-resistant qualities are another threat to wool in the clothing industry. Union Carbide has developed Dynel and Vinyl, fibers from vinyl resins that are favored for industrial uses where resistance to chemical corrosion is a requirement. Dow Chemical Co. enters the field with Saran made from a synthetic resin. Fibers from glass in the form of yarns, staple, and mineral wool have a wide use as insulating materials and in the plastics industry and as tough, fire- and weather-resistant fabrics. The United States produces nearly 80% of the world total of these "noncellulosic" fibers which, however, is less than one tenth as great as the world production of rayon and acetate (see Table *29:7*).

The list is long, and this year's list would be out of date next year. Nor does the United States have a monopoly on the development of man-made and synthetic fibers. The technology of rayon was originally imported from Europe, and the chemical industries of Europe, Russia, and Japan have not stood still in the intervening decades.

7. THE PLANT-STALK FIBERS

Machinery has revolutionized the textile industry by giving it new ways to produce its old results. It has revolutionized it also by giving the new seed fiber, cotton, in place of the stalk fiber, linen; and more recently by producing a host of man-made fibers. It may cause further revolution by enabling us to use other cheap stalk fibers. Several thousand plants contain fibers of good quality for various uses, if they could be secured in cheap abundance, and several dozen such fibers are actually in extensive use in various parts of the world. There is no guarantee of the continuance of cotton's leadership in plant fibers, as some stalk fiber cheapened by machinery may some day supplant it.

Flax fiber and its preparation. Flax is

[20] Product research and development and plant construction required an investment of $65 million before production started in the new Dacron plant at Kinston, N. C. Here is a major reason why development of synthetic fibers is a function of large organizations in industrially mature countries.

now, as in the past, the most important plant-stalk fiber used in clothing. In the eighteenth century flax was the most important of all vegetable fibers and was grown on almost every European and American farm. The introduction of cheap cotton caused the disappearance of flax from gardens at about the time that the spinning wheel and the hand loom disappeared from homes.

The plant is somewhat branching, but otherwise resembles the small cereals in appearance and method of cultivation. For the fiber it must be pulled, piled up to dry, and the seed removed with an iron comb; then the straw is "retted"—a process of partial decay to make easy the separation of fiber. In some places it is retted in bunches, spread upon the ground of moist meadows; in others, as in Ireland, it is immersed in water. In Belgium, where a small flax industry still survives, the water of the River Lys is of peculiar fitness in retting flax, and in it flax straw, some of which is imported from France, is immersed so that the pulp is partially decomposed, allowing the fiber to be more easily separated. This is done by running the straw through rollers, after which the fiber may be separated by hand or by passing the straw through a machine with dull knives. Fibers thus obtained are from 8 to 50 inches in length, strong and durable; but since the coming of cotton, the labor of getting the flax fibers out of the stalk has made its production impracticable wherever wages are high and import of commercial products easy.

Flax is unquestionably superior to cotton for many uses, but from the standpoint of competition on the point of cost, it rests under yet other handicaps. Although flax grows in a far wider range of climate than cotton, it is much more easily injured by drought or wet weather, and the difficulty of preparing it gives lack of uniformity, a serious handicap to the manufacturer. The fiber is harder than cotton to manufacture, requiring more power and more labor. Machinery has increased the linen spinner's efficiency only about one half as much as it has the cotton spinner's efficiency.

Distribution of fiber flax. The flax plant has an exceedingly wide range, having produced good fiber all over the eastern United States and on the other side of the Atlantic, from Algeria, Italy, and Yugoslavia to Scotland, Sweden, and Russia. The cultivation of the flax plant for its fiber, like silk culture, shows a decided response to labor conditions —density of population. In sparsely peopled areas, such as Dakota and Argentina, the laborious hand processes of harvesting and preparing flax are impossible, but they fit well into the scanty opportunities of the cold Baltic shores and of Russia, the world's leading fiber flax area. Prior to World War II the Soviet Union produced about 70% of the world's flax, an average of 560,000 tons coming from the northern fringe of the agricultural area in central and western European Russia. Even with the incorporation of important flax-producing areas in Poland and the Baltic States, the U. S. S. R.'s postwar production was only 345,000 tons (1948), but still amounted to 60% of the world total. Better quality fiber and higher yields per acre are obtained in a limited area of northeastern France, Belgium, and Holland—which produced 65,000 tons in 1950.[21]

Ramie. One of the best of the Oriental plant fibers, ramie is much used as a substitute for linen. Ramie and China grass are the same thing at two different stages of manufacture, China grass being the name for the rough brown fibers which are called ramie when bleached out. The fibers are both stronger and have a longer staple than any other natural fiber. Similar to silk in appearance, ramie is more water-absorbent than cotton, resists decay in water and has nonshrinkable proper-

[21] During World War II the output of flax increased greatly in the United States, Great Britain, and the British Commonwealth, only to decrease just as rapidly after the close of hostilities. Woytinsky, *op. cit.*, pp. 614–615.

ties. It is therefore excellent for a wide variety of uses from tarpaulins and rope to clothing and household fabrics. Since the fiber can be woven on standard textile machinery it may also be combined with other fibers.

Ramie thrives best in temperate climates where the danger of frost is at a minimum and on a considerable variety of soil types. It is widely grown in southern China, the chief source of China grass, and has been used as a clothing material in Japan. Considerable experimental work has been done on the production and processing of ramie in southeastern United States with commercial developments under way in the Florida Everglades. The major bottleneck, as with most plant-stalk fibers, is the development of decorticating machines to remove the fiber in competition with cheap hand labor. Degumming the fiber is an additional problem. World War II fiber shortages stimulated development along these lines, and there is now a strong possibility that ramie will emerge as a significant competitor with natural and man-made fibers.[22]

Hemp. Hemp, the fiber of common cordage, is closely allied to flax, of which it is really but a coarser variety and therefore fitted for coarser uses. The fiber is separated from the stalk by processes similar to those used in flax preparation and, like flax, is mainly a European product. About a third of the world's supply is produced in the seed-flax area of central European Russia, with an additional 50% from other parts of Europe—chiefly Italy, Yugoslavia, and Rumania. Italy produces the highest-priced hemp fiber, which is imported into Great Britain, Germany, and the United States for commercial twine, coarse toweling, and carpet yarns. In the United States there is the familiar story of expansion of hemp acreage from almost nothing to 146,000 in 1943 and, with the relaxation of wartime pressures, a decline to 1000 acres by 1951. Hemp fits well into the rotation scheme in the Corn Belt, but labor-wise it is uneconomic in U. S. agriculture. Another difficulty in the expansion of hemp acreage is the fact that the plant is a major source of the narcotic drug marijuana. Its production is therefore prohibited in various parts of the world and strictly supervised in others.

Jute. Practically all the world's supply of jute, the cheapest fiber in general use, comes from Bengal, where the densely populated deltas of the Ganges and the Brahmaputra rivers provide optimum conditions for its growth and processing. Jute requires a tropical climate with high temperature, heavy rainfall, and much sunshine. It also makes heavy demands upon the soil and so does best on flood plains rejuvenated by annual overflow of the rivers. Like flax, hemp, and many other fibers that are not gummy it is separated from the stalk by being soaked in water. This requires much unpleasant labor by workers standing hip-deep in water, and the best quality fiber results if the water is relatively clear and not stagnant. These conditions are widespread throughout Bengal and small portions of neighboring provinces, but the optimum combination is found in East Bengal along the Brahmaputra and other rivers from the nearby mountains.

Under the British, Bengal developed a virtual monopoly in jute production which it still enjoys. East Bengal, with the larger acreage, higher yields and better quality, produced about three fourths of the total. Calcutta, in West Bengal, was the export port and processing center through which moved more than 95% of Bengal's commercial production. Here it was baled for export as raw jute, and about half the crop was manufactured into cloth, burlap sacks, and twine in the jute mills that line Calcutta's Hooghly River. These mills contain about 60% of the world's jute looms.

---

[22] A full-page advertisement in *The New York Times*, Sunday, June 6, 1954, paints a glowing picture of ramie possibilities and offers stock in a Florida corporation already in production. For a more balanced analysis, see Stephen L. Lemar, "Prospect for Ramie in the Lower South," *Journal of Geography*, February 1947, pp. 43–54.

Another third are located in western Europe, especially France, Germany and Great Britain where Dundee is the largest center.[23] Most of Bengal's raw jute naturally went to the mills of western Europe. The United States was the chief market for manufactured jute, which Calcutta also exported in competition with European mills to other countries shipping the world's cotton, wool, wheat, coffee, etc. Smaller amounts of jute cloth and twine are used in a wide variety of products, but its major utilization was and remains as a cheap, strong, sacking material.

TABLE 29:8. World Jute Production
(millions of pounds)

	1935–39 average	1947–51 average	1953[a]
India	3361	1179	1400
Pakistan	[b]	2237	1001
All others	61	104	130
World	3422	3520	2531

a Preliminary.
b Included with India.
Source: USDA, *Foreign Crops and Markets,* November 30, 1953, p. 419.

Here is evidence of Bengal's continued supremacy in the world of jute. Production in 1953 is one of the lowest on record following after near-record production in 1952, when India produced 1.9 and Pakistan 2.7 of the world total of 4.7 billion pounds.

These world relationships have been little changed in recent years. But the economic geography of the major producing area has been greatly altered by the partition of Bengal. The optimum producing area in East Bengal is now in Pakistan and separated—by a national boundary and international friction—from Calcutta, its traditional port and manufacturing center. Pakistan now bales its own jute, expands its ports, is attempting to build a milling industry, and restricts acreage to maintain prices for raw jute. Meanwhile India, separated from a major source of its raw material, has expanded jute production in West Bengal and nearby areas to supply the Calcutta mills. Political developments have thus bisected a functioning economic unit with, as a result, Pakistan's duplication of existing transportation and processing facilities and India's expansion of jute production in less favored areas.

Despite these local difficulties no rival area[24] has a comparable combination of advantages. Bengal continues to supply at least 95% of the world's jute (see Table 29:8). Jute faces stronger competition from other fibers, as well as from the use of paper bags and cartons and the development of bulk handling as substitutes for the ubiquitous burlap sack in commodity transport. Nonetheless, jute will continue in great demand with Bengal as the major source of supply.

8. THE HARD FIBERS

Hard fibers from the leaves and leaf stems of tropical plants are the chief raw materials for rope, twine, and string. There are three such fibers in important commercial use and each has its major producing area: abacá from the Philippines, henequen from Mexico, and sisal from Africa.

Abacá (Manila hemp). This best of rope materials is not hemp at all, but a coarse fiber sometimes 8 to 10 feet long, found in the pithy leaf stem of the abacá, a fruitless member of the banana family. Like the banana, abacá needs fertile soil, moist climate, and the plant is easily damaged by wind. It does not do well on water-soaked or on dry soil, and a rainless period of only a few weeks reduces yields and may kill the plant. The eastern and south-

[23] In the 1830's linen manufacturers of Dundee began the machine spinning and weaving of jute. So great was the demand for this cheap bagging material for the shipment of growing agricultural surpluses that Dundee shifted from linen to jute. In the 1850's Scottish technicians and machines were brought to the Hooghly and founded an industry that not only displaced local jute handicraft production but ultimately surpassed the original center. Robert C. Kingsbury, *The Jute Industry of India and Pakistan, with Emphasis on the Changes Resulting from Partition of the Indian Subcontinent,* unpublished M. A. Thesis, Department of Geography, University of Kansas, Lawrence, 1951.

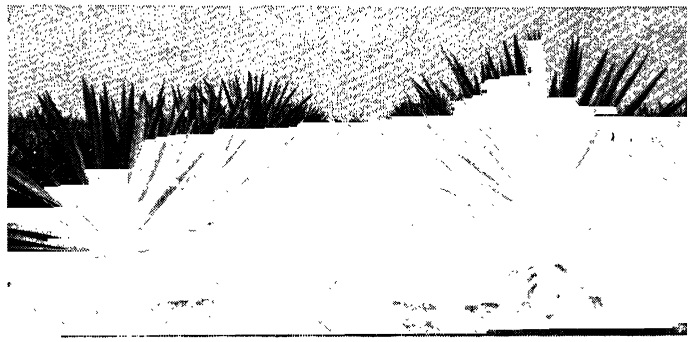
[24] In the Amazon Valley, Japanese settlers now produce 40 to 50 million pounds of jute per year. While this subsidized effort may make Brazil self-sufficient in jute, it constitutes no export threat to India-Pakistan.

ern Philippine Islands, as far north as southern Luzon, is the major producing area favored by climate and fertile volcanic soils. The Filipinos were the first to domesticate the plant and for centuries abacá has been an item of export.

This plant conspires with the climate to keep the Filipino from steady work. Man does not usually like to work regularly, and it is often not necessary in the productive climate in which fortune has placed the Filipino. He can from time to time plant a few suckers of the abacá plant, and in two or three years he can cut them down, split them into strips a couple of inches wide, scrape away the pulp with a sharp knife, and sell the long, white, shiny fiber to Chinese merchants.

The supply-demand relationship is often the reverse of the version expounded in our texts on economics. When abacá prices are high the independent farmer needs to produce only a small amount, but when prices are low he must strip more to meet his modest need for cash. This situation has very unsettling effects on the abacá market, as it does on various other tropical products for which the small, independent native producer is an important source of supply.

Near Davao, on the sparsely populated island of Mindanao, large abacá plantations were worked by laborers from more populous islands. By 1941, 200,000 acres (two thirds controlled by the Japanese) produced about half of the Philippine crop. Costs of production were lower, owing to large-scale operations and the use of machines to strip the fiber.[25] But these plantations were practically wiped out by World War II and the removal of the Japanese. Subsequent recovery has been hindered by plant diseases. Since World War II production has been substantially below the prewar average (see Table 29:9), and the small-scale native producer is again the chief supplier. This decline presents a major problem since abacá has always been among the first four items in Philippine export trade, with the United States taking over half the total in recent years.

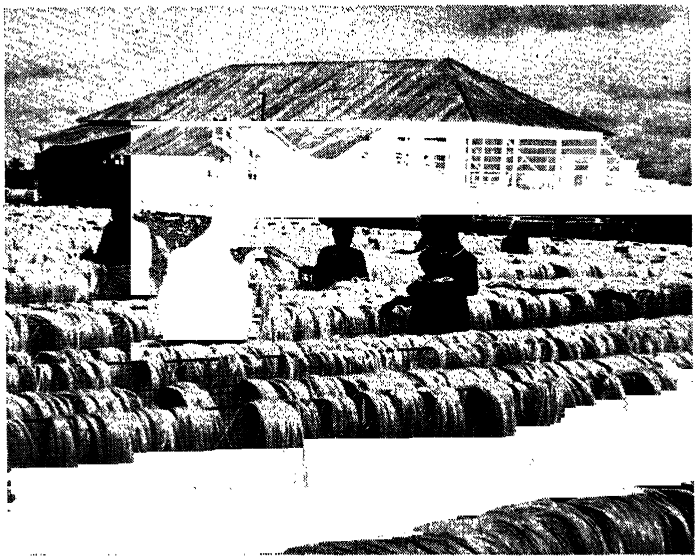


Henequen (sisal) plants, 8 feet high. A crop for semiarid tropics. ***Henequin Association, Merida, Yucatan***

Attempts at introducing Manila hemp growing into other parts of the world have been slow, and for years the Philippines enjoyed a monopoly comparable to Bengal's for jute. Small amounts were produced in Borneo and the East Indies. More significant were the efforts of the United Fruit Co. to develop abacá production on abandoned banana land in Central America (see p. 139). Supported by U. S. government contracts during and since World War II, production in Central America rose to 34 million pounds, about 11% of the world crop in 1952. Production costs are higher than in the Philippines, and the Central American plantations are likewise troubled by plant diseases. Balancing advantages are the higher degree of mechanization, the nearness of Central America to consuming markets, and the strategic interest of the United States in Western Hemisphere sources for this important fiber. Central America cannot surpass the Philippines, but it is also unlikely that the Philippines can regain their former monopoly position.

Henequen. The rise of the henequen industry came about when the self-binding reaper caused a new demand for cheap twine about 1880. This article of commerce was obtained

[25] About 600 pounds of fiber can be machine-stripped per man-day in contrast to 30 to 40 pounds by hand methods. J. E. Spencer, "Abacá and the Philippines," *Economic Geography*, April 1951, pp. 95–106. Citation on p. 96.



Sisal fiber. A plant much like henequen. British East Africa leads, chiefly Tanganyika and Kenya. Here women are removing defective fibers. Each leaf 1000 fibers. Note children. *British Information Services*

from the long, tough fiber in the thick heavy leaves of the henequen plant, which grows wild over much of the dry limestone plain of Yucatan near Progreso. Henequen growing on a commercial scale soon became a capitalistic enterprise, the plants being set out 3 to 10 feet apart in hand-made holes in the unplowable rocky soil by Maya laborers. Rival vegetation is chopped down with a machete until the plants are grown. After this they yield 10 to 15 leaves every six months for 10 to 20 years. One man with two assistants will cut, trim, count, tie into bundles (25–50 leaves to a bundle), and carry to a roadway 3000 to 4000 leaves a day. Tramways carry the heavy leaves to engine-driven machines that tear out the 3% (by weight) of fiber, which is then dried and pressed into 35-pound bales for shipment. In a few decades Yucatan has become the commercial slave of henequen, just as our South once was of cotton, this one product making up 95 to 98% of the export of Yucatan, which amounts to about 85% of the world total. This one money crop buys much of the food, even corn in considerable quantities being imported.

Cuba has the most promising rival henequen plantations at the present time; her half-dozen large plantations comprise about 37,000 acres.

Small amounts of henequen are consumed by cordage manufacturers in Mexico and Cuba but the great bulk of the fiber is exported, and its major use is in the manufacture of binder twine. It does not make as good twine as Manila hemp but is good enough and usually cheaper. Henequen and sisal also compete with Manila hemp in the manufacture of cheaper grades of rope, although the latter remains supreme for ship rigging and marine hawsers since it does not weaken or swell in sea water. When worn out for this use, it is ground up to make the exceedingly strong paper known as Manila.

The displacement of binders by combine-harvesters in the world's grain fields means less demand for binder twine. Fortunately for the henequen producer, the pick-up hay baler uses binder twine and this development (at least in the United States) partially compensates for the decrease. However, henequen production has declined from a modest wartime peak, and in 1952 was almost exactly at the prewar level (see Table 29:9) with almost no change in the relationship of the major producing areas.

Sisal. Henequen and sisal are different but closely related species. Both are drought-resistant perennials, which can be grown in dry climates and on relatively infertile soils—in

TABLE 29:9. Hard Fiber Production—World and Leading Producers
(million pounds)

	1934–38	1946–50	1952
Abacá			
Philippines	376	171	247
World total	387	203	296
Sisal			
British East Africa	261	335	447
World total	507	552	830
Henequen			
Mexico	212	244	212
World total	247	282	246
Total hard fibers	1141	1037	1372

Source: USDA, FAS, *Foreign Agricultural Circular*, June 5, 1953, pp. 2–3.

striking contrast to the moisture and soil requirements for jute and abacá. Sisal has more tensile strength than henequen and, though less strong than abacá, is the latter's chief competitor in the rope industry. It is also used for bags, floor coverings, bristles, twine, and upholstery tow.

Africa is the leading producer of sisal, although the plant was imported from the Western Hemisphere. More than half the world crop comes from Tanganyika and Kenya where sisal is the leading commercial crop and export. In the Western Hemisphere, Haiti has long been a small producer, while rapid development has led Brazil to displace the East Indies as the second most important producing area. Indonesia now produces only a third of its prewar average.

In contrast to the other two hard fibers, sisal production has increased substantially since 1945. This is owing to the qualities which make it competitive with the other two and to the fact that it was produced in all three of the major tropical land areas. Also, since 1945 European consumers have turned more to sisal since it is the only hard fiber produced outside the "dollar area."

Inter-fiber competition. The natural fibers have developed rather well-defined uses within which there is much competition. Wool and silk are primarily apparel fibers. At the other extreme, the hard fibers and the plant-stalk fibers (excepting flax) are destined mainly for industrial uses. Cotton, still King, plays a field which includes these two extremes. Despite this apparent separation, there has long been intensive competition among the fibers, for, as we have seen, one or more fibers can generally be found suitable for a given purpose.

This complex situation has been intensified by the development of man-made and synthetic fibers that brings industry into direct competition with agriculture. Their production is not directly dependent on cropland, sheep pastures, or mulberry trees but can be carried on wherever an industrial plant can be operated successfully. Once the experimental stage is past, synthetic fibers and filaments are more uniform in quality than most natural fibers, and their price is less subject to short-term fluctuations. With increasing output there has been a long-term tendency for costs to decline as a result of the economies of large-scale industrial production. This increases competition among the synthetics and also between them and the natural fibers. So far, only silk has suffered an actual decline in production, but the other natural fibers must increasingly share the expanding market for textile goods with these products of industry.

30· The Textile and Clothing Industries

The making of cloth from fibers is one of man's most ancient manufacturing activities. Linen cloths have been found in prehistoric lake villages of Switzerland, and linen mummy cloths found in Egyptian tombs date back to 5500 B.C. and some even to 12,000 B.C. Cloth was made from cotton in India 5000 years ago and has been found in prehistoric ruins in North and South America. The manufacture of woolens was developed to a high art by the Romans, and silk textiles are at least as old in the Orient.[1]

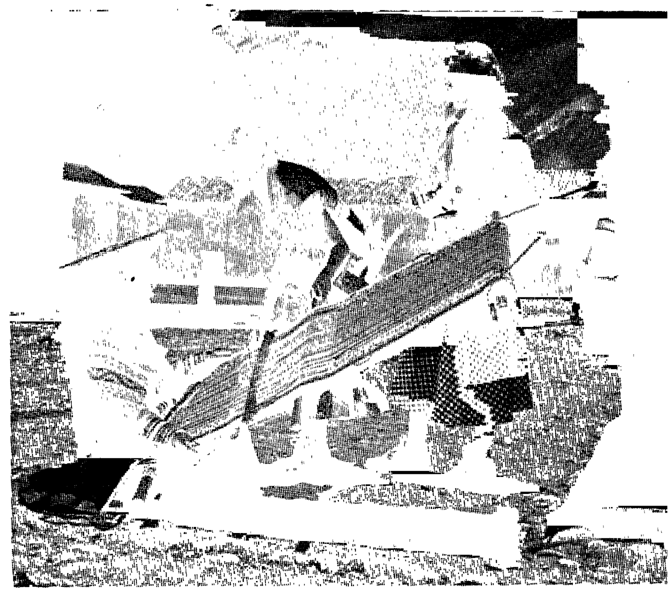
The modern textile industries form an important, complex, and highly developed part of industrial society. They have long been important in the world's major industrial regions. But they have also spearheaded industrial development in many so-called "backward" areas. As a result, striking changes have occurred in the location of these industries and in the trade in raw materials and textile manufactures.

1. MANUFACTURE AND TRADE IN COTTON CLOTH

Spinning and weaving in the hand-labor era. Fibers of any sort, including hay, when twisted around each other tend to cling together and form a continuous thread or yarn. During most of the Christian era, the material to be spun was held on a distaff, a stick under one arm, and the yarn, often twisted by a process like spinning a small top between thumb and finger, was, when finished, wound upon a spindle (Fig. 531 left). The spinning wheel, used several centuries ago in the Far East, was also independently invented in several parts of Europe in the fifteenth century, and was scattered over the world wherever European colonists went. The yarn thus laboriously spun was woven into cloth on hand looms, the industry being carried on in the homes of the workers even when the product was intended for sale. Some people were spinners, others did the weaving, and cloth making for sale was a common household industry throughout the Western world in the middle of the eighteenth century. There was a considerable trade in textiles and fine cotton goods produced by the skillful but poverty-stricken hand-loom weavers of India and exported to England and western Europe.

Textile machinery and the factory system. By the mid-eighteenth century, hand-spun and hand-woven fabrics were produced in towns and rural areas throughout much of England and southern Scotland. Wool was the major raw material, while flax, for the linen

[1] W. S. and E. S. Woytinsky, *Population and World Production—Trends and Outlook*, Twentieth Century Fund, New York, 1953, p. 597.



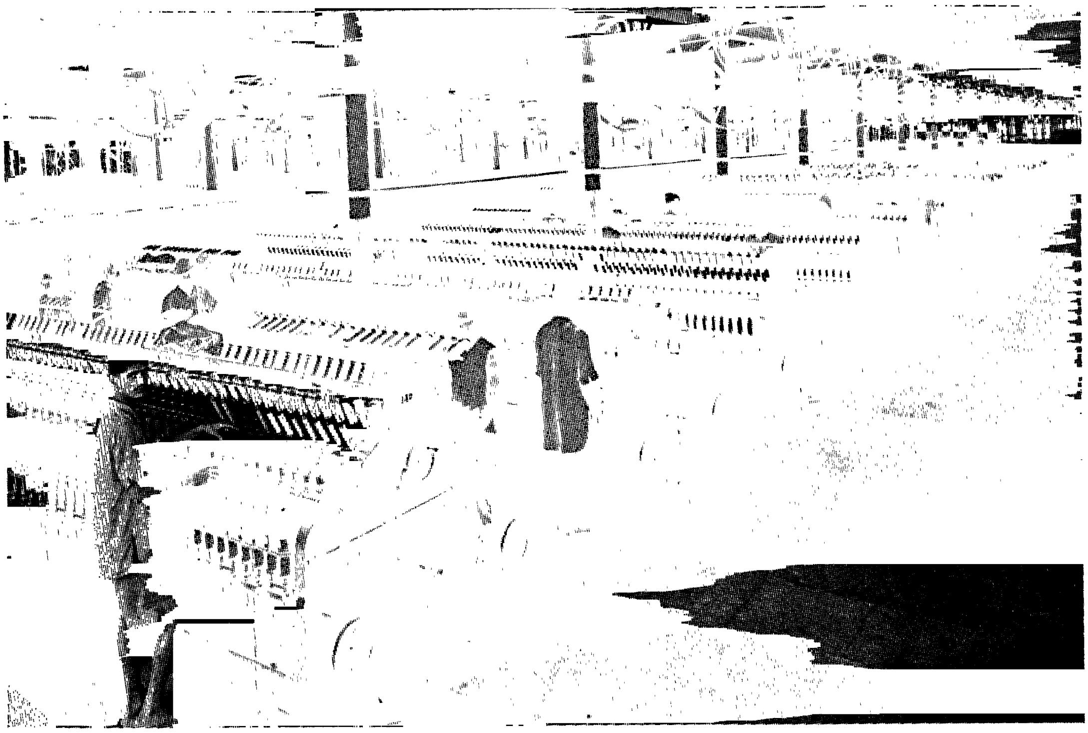
(Left)* Italian woman spinning. We have seen it. With right hand she spins the spindle, pulls out cotton to form the thread, stops, winds it on spindle, repeats. *(Right)* Pisac, Peru. Indian weaving. Hold your pride. Archeologists say the finest cloth in the world was made here 500 years ago. *Panagra

weavers of west Lancashire and the Scottish Lowland, was much less important. Only a little cotton was used, chiefly in making "fustian"—a cloth with linen warp and cotton woof.

This was the setting for some of the most dramatic developments of the Industrial Revolution. A series of inventions—Hargreaves' spinning jenny (1764), Arkwright's "water frame" or throstle (1768), and Crompton's "spinning mule" (1779)—mechanized the spinning process and moved it from the household or small workshop into the factory. For a few years there was a great surplus of yarn until Cartwright's invention of the power loom enabled weavers to use up the yarn produced on the spinning machines. Thus, the spinning machine demanded the weaving machine, and both demanded a cheaper, more abundant fiber. In answer to this demand came the cotton gin (1793), six years after the power loom had made cotton acutely scarce. Cotton quickly became cheap. This combination of spinning machines, weaving machines, cheap cotton,[2] and the coal and the iron resources of England enabled that country to forge rapidly ahead in cotton manufacture while all the continent of Europe was disturbed with the turmoil of Napoleon's wars.

The short period of 30 years between 1785 and 1815 produced greater change in British industry than many previous centuries had made. It has been well called the Industrial Revolution. Before this revolution, man used little artificial power, and the manufacturer often lived in the village or in the country where he gardened, kept some livestock, and worked on nearby farms. He was near to the food supply and had opportunity to use his extra time to good advantage. Industry was organized around a man's time. After the Industrial Revolution, the worker found himself living in a city tenement to be near some

[2] These early changes from hand to power-machine methods of production increased labor productivity 200 fold in spinning, 50 fold in weaving, and 50 fold in roller ginning. And this was but the beginning. R. Robson, "Location and Development of the Cotton Industry," *Journal of Industrial Economics,* April 1953, pp. 99–125. Citation on p. 107.



Spinning room, India. Machine whirls the spindle, hundreds of them per worker. ***Government of India Information Service***

other man's steam-driven machine in the big factory. Industry was organized around a machine, *a machine's time*. Man was away from the earth, the one great resource. He had no chance to produce food in his odd moments and was dependent upon the factory wage and imported food. The Industrial Revolution has spread and brought these characteristics of urban-industrial society to many parts of the world. The man away from earth increases his output of goods and personal frustration.

Present distribution of cotton manufacture. During the nineteenth century, textile machinery was exported to many countries, and cotton cloth traveled to the ends of the earth. The spinning wheel and the hand loom almost disappeared before the steam-borne commerce in ever-widening circles. Britain's early leadership and dominance in cotton manufacturing—as shown by her leadership in the number of spindles, cotton consumption, and export of cotton goods—continued through most of the nineteenth century.[3] But the basis had been laid for Britain's abrupt decline, which followed World War I. By 1900 continental Europe and the United States had developed cotton manufacturing on a large scale. After 1900 the cotton-textile industries of India, Japan, and China expanded rapidly, while smaller developments were taking place in many other parts of the world (see Table 30:1).

As a result, the cotton-textile industry has become the most widely spread of our major manufacturing industries—located in old industrial areas as well as those in their early stages of industrialization; in cotton-producing regions as well as localities hundreds of miles from the nearest cotton field; in seaports and also interior centers; in countries with a high standard of consumption and pur-

[3] In the years 1910–13, Great Britain still had about one third of the world's cotton spindles, consumed about one fifth of the mill-processed cotton, and accounted for nearly three fifths of the world's export of cotton goods. Robson, *op. cit.*, p. 115.

chasing power as well as those where the mass of people are living at the margin of subsistence.

Several characteristics of this industry help to explain this locational diversity and spread. In the first place, there is a ready market for its product wherever there are people. Cheap cottons clothe millions in the agricultural areas of the world, and in India and China yarn spun in modern mills is still woven on hand looms. Secondly, the processes of the industry are relatively simple—especially for the coarser goods in greatest demand—so that a cotton mill can make use of untrained labor fresh from the farm. Thirdly, since labor costs are important, such a labor supply is often an advantage for the industry, and there are numerous examples of its rapid expansion in low-wage areas. Fourthly, the cotton mill requires a relatively small capital investment in contrast to the giant factories common to the chemical, metallurgical, and some metal-fabricating industries. A mill producing coarse to medium yarn or cloth is comparatively simple to set up and can quickly begin production and a return on the investment. Finally, although raw cotton is the major item of cost, it has relatively little influence on the location of the industry. Cotton is produced in many areas, and, when ginned and baled, it is a compact and relatively high-valued raw material which can be economically transported. Further, there is little reduction in bulk in the manufacturing processes. Consequently, nearness to raw material supply is not a major locational consideration for the cotton manufacturer. Widespread market, simple processes and labor requirements, moderate-sized plants, and relative freedom from locational dependence on raw-material supplies, all contribute to the locational flexibility of the cotton-textile industry and help to explain why it has often been the opening wedge of industrialization.

TABLE 30:1. Millions of Cotton Spindles in the World

	1900	1913	1929	1938	1953
Europe					
United Kingdom	45.5	55.7	55.9	36.9	27.3
Rest of Europe[a]	32.5	44.1	48.4	49.7	44.9
Total Europe	78.0	99.8	104.3	86.6	72.2
United States					
Cotton states	4.4	12.2	18.5	18.1	18.1
Other states	15.1	19.3	13.9	6.7	3.3
Total U. S.	19.5	31.5	32.4	24.8	21.4
Asia					
India-Pakistan	4.9	6.1	8.7	9.7	12.1
Japan	1.3	2.3	6.5	12.6	7.5
China	.6	.9	3.6	4.3	4.4
Total 3 countries	6.8	9.3	18.8	26.6	24.0
All other countries	1.5	2.8	6.3	7.6	10.3
World total	105.8	143.4	161.8	145.6	127.9

a Including Russia.
Sources: Compiled from publications of the U. S. Bureau of the Census and the International Federation of Master Cotton Spinners' and Manufacturers' Associations (Manchester, England).

British leadership in cotton textiles. For more than a century the name of Manchester, the metropolis of Lancashire, has been synonymous throughout the commercial

world with cotton cloth. The hand spinners and weavers of textiles in Lancashire had imported flax and cotton, used local wool, and exported cloth for decades before the advent of power spinning and weaving in the late eighteenth century. The new cotton mills found favorable conditions in Lancashire, which quickly became dominant in the British industry and remains today the greatest concentration of cotton-textile capacity for an area of its size in the world. One advantage was the air from the Atlantic that brought moisture so necessary to the best cotton manufacturing. These same Atlantic winds influenced the development and locational pattern of the industry through the water power of numerous small streams that descended from the central highlands (known as the Pennine chain) and led to quick development after the invention of the new machines.

With the advent of steam, the Lancashire coal field provided a local source of fuel. A fourth factor in Lancashire's dominance was the convenient harbor of Liverpool, which has long had wide ship connections with regions producing and consuming raw cotton. The city of Manchester itself has long ceased to be so strictly a manufacturing city, and has become the sale and storage center for the product of many surrounding towns. With the construction of the Manchester Ship Canal early in this century, ocean vessels were able to unload cotton directly on Manchester's docks, although the port has been less of a competitor with Liverpool in the export of cloth.

It is, indeed, surprising that in a century and a half the British cotton industry should have spread so little beyond the radius of 40 miles from Manchester. This district still manufactures nine tenths of Britain's cotton textiles, about one third of which were exported in 1949–51. Within Lancashire there is also a striking geographic separation of spinning and weaving. In the United States these two processes, and often finishing as well, are generally carried on in the same factory. In England, however, they are mostly done in separate establishments, which makes possible (but does not cause) a geographic separation. Spinning predominates in southern Lancashire, where nine tenths of Britain's spindles are in mill towns located on the west slope of the Pennines and the south side of the Rossendale Moors (a westward extension of the Pennines) thus forming a rough semicircle from Bolton to Stockport, around Manchester as the center. Weaving, on the other hand, is dominant north of the Rossendale where such towns as Burnley, Blackburn, and Preston contain three fourths of Lancashire's looms.[4]

Great Britain had led all countries in the manufacture of cotton goods because she had the great advantage of an early start, no wars on her home soil, the ready use of capital while others had to borrow, the most wide-reaching shipping connections, and the local advantages of unrivaled coal, iron, and harbors. Because of her tariff policy, she had cheaper food than any Continental country, and she had cheaper cash wages than the United States. As a result of all these advantages, the equipment and also the operation of a cotton mill was much cheaper in Lancashire than in many other areas during most of the nineteenth century. Natural advantages are only part of the explanation. Other areas in Britain—the Scottish Lowland, for example—were similarly endowed with moist climate, water power, coal, and harbors. But the concentration and specialization of cotton mills in Lancashire themselves created an "attractive force" for the industry over and above the natural advantages which Lancashire shared with other areas.

Britain's decline. The British cotton-manufacturing industry, which reached its peak before World War I, has declined, however, owing to the competition from newer

[4] The geographic specialization goes even further, with individual weaving towns concentrating on different kinds of cloth and spinning centers on certain qualities of yarn. For a fuller explanation of these economic-geographic patterns, see Wilfred Smith, *An Economic Geography of Great Britain,* E. P. Dutton & Co., New York, 1948, pp. 462–478.

areas and to the fact that former outstanding advantages no longer are important.[5] Her early start meant antiquated machinery and inefficient organization, resulting from the industrial disease called conservatism. It is almost endemic in the third generation of successful families. Artificial humidifiers can moisten the driest of air, while inventions and mechanical improvements lessen the significance of skilled labor.

In 1913 Britain exported 7 billion yards of cotton cloth, over 80% of her production. By 1949–50 exports had dropped to an average of 860 million yards, roughly a third of her production. Instead of supplying three fifths of the world's cloth exports (cotton content basis), she now supplies less than a fifth. Particularly disastrous for Lancashire was the 90% decline (1913–37) in exports to India and the Far East, which had taken over half the total in the years before World War I.[6] By 1930 India and China were self-sufficient in cotton manufactures, and Japan was a major exporter. In general, about two thirds of the decline in British exports prior to World War II was attributable to the rise of the cotton industry in importing countries, and the remainder was due to the competition of Japan on the export markets. Only by specializing in high-grade textiles has Britain been able to maintain an important position in the world picture.

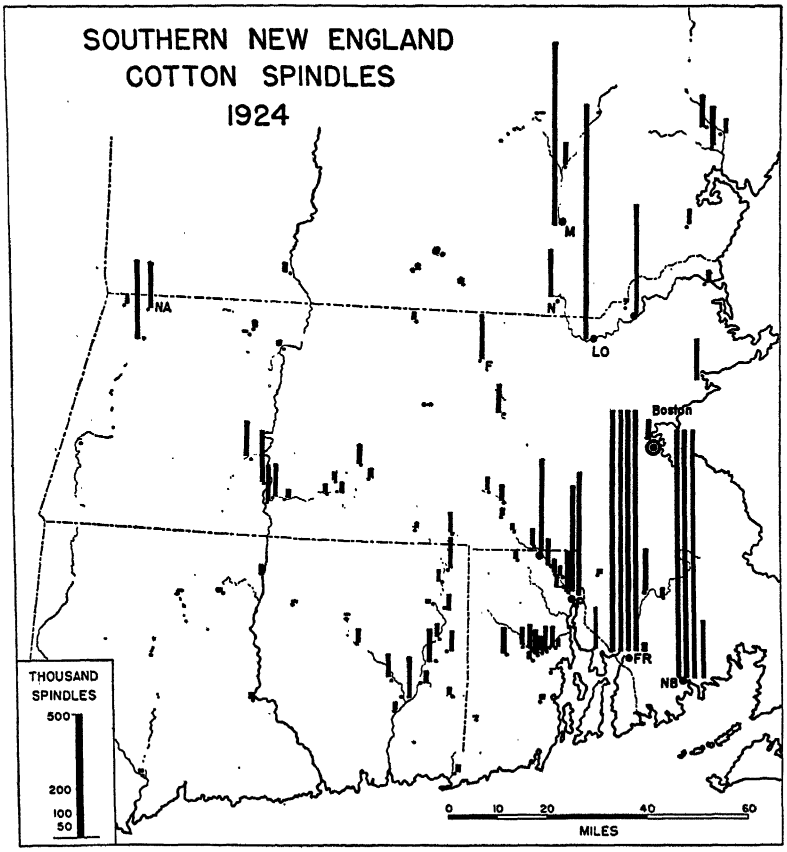
Cotton industry on the Continent. The continent of Europe has more spindles than Great Britain. Owing to the coarser product produced, there is an even greater relative consumption of raw cotton. Bremen, Le Havre, Genoa, and Barcelona are the chief importing points, and the greatest centers of manufacture lie between the Elbe River and Paris, the North Sea, and northern Italy. This area includes northeastern France, where Lille is the leading cotton mill center, and the populous Rhine Valley, with a host of manufacturing towns in Germany, Holland, Belgium, and Switzerland, and Alsace in eastern France, in all of which fine cottons are made for home consumption, and for export. Northern Italy is another important district. Here the water power from the Alps is being utilized for the manufacture of cotton as well as other textiles. Landlocked Switzerland, with its long tradition of skilled craftsmanship, has a per-capita export of high-grade cotton manufactures (chiefly laces and embroidery) greater than Britain herself. Barcelona is the center of Spain's cotton-mill district, and, like Italy, a modest export is partly due to the fact that domestic consumption is low because of widespread poverty. In all these areas, as in Britain, textiles were produced in the period before the Industrial Revolution. Today there is a complex intermingling of modern mills, small workshops, and even handicraft production in the homes.

In eastern Europe, the Soviet Union has an estimated 10 million cotton spindles. The traditional and still major area is in the central industrial district around Moscow and Ivanovo-Vosnesensk; although, in the effort to reduce transport costs and spread industry, the Soviets have built some mills in the cotton-producing districts of Russian Central Asia, the Caucasus, and in the growing industrial centers of western Siberia. The Polish city of Lodz, often spoken of as "little Manchester," and textile centers in populous Bohemia, a part of Czechoslovakia, are important producers from which cotton manufactures were exported prior to World War II.

Cotton manufacturing in the United States. The cotton-mill industry has nearly as long a history in the United States as in Great Britain. With the decline of Lancashire, we have become the world's leading producer of cotton textiles, a natural result of our leadership in raw-cotton production and our large domestic market. The develop-

[5] "The Lancashire cotton industry . . . is perhaps the outstanding example of how acquired advantages can retain an industry in one location long after other advantages of the location have largely disappeared. . . ." Robson, *op. cit.*, p. 112.

[6] During this period, exports to non-Asiatic markets declined by 49%. Only a few small African markets showed absolute increase. A. E. Kahn, *Great Britain in the World Economy*, Columbia University Press, New York, 1946, p. 94.



Three eras here: (1) along small streams in eastern Connecticut, Rhode Island, and central Massachusetts; (2) after 1820, larger powers Manchester (M), Nashua (N), Lowell (L); (3) after Civil War, steam power at ports, Fall River (FR) and New Bedford (NB), and expansion of inland water power. For the fourth era, see Fig. 537. *Thomas R. Smith*

ment of this industry has been accompanied by a major shift in its location from New England to the southern Appalachian Piedmont.

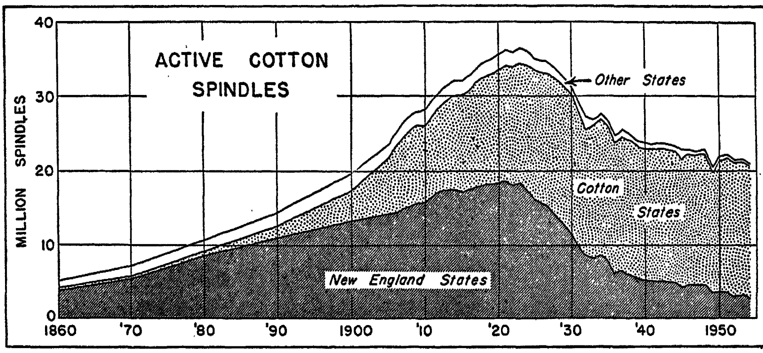
New England—an old textile area. The Englishman Samuel Slater came to Rhode Island in 1790 with the plans of Arkwright's spinning machinery in his head. Here he built America's first successful cotton mill. From this early beginning, the mills quickly spread along the waterfalls of New England's glacial streams and rivers from the Androscoggin in Maine to the Hoosic in western Massachusetts and the Thames in Connecticut. The Merrimac had falls of more than 50 feet at three places, and at these three great textile towns arose: Lawrence and Lowell in Massachusetts, Manchester in New Hampshire.

By 1860 most of the water-power sites in southern New England had been occupied, and the steam engine had been developed to a point where it could be effectively used for driving cotton machinery. The era of water power was over. Expansion, mostly based on steam, continued at the water-powered mill centers, but mill towns near the coast of Rhode Island and southern Massachusetts grew more rapidly. Transport costs of coal and cotton were slightly cheaper, and this area was more convenient to New York's cloth markets and clothing manufacturers. At the peak of New England's cotton manufacturing, Fall River and New Bedford, with over 7 million spindles, were the world's leading cotton-mill towns, and nearly two thirds of New England's cotton-textile capacity was in this area (see Fig. 536).[7]

The New England textile labor situation

[7] T. R. Smith, *The Cotton Textile Industry of Fall River, Massachusetts,* King's Crown Press, New York, 1944, gives the record of the amazing ups and downs of an industrial center in the flux of changing locational conditions.

When the New Englander wanted to enlarge after 1920, he built a factory in the South. Total spindles declined one third, 1924-54, but cloth increased one fourth due to better machinery and double shift. *U. S. Department of Commerce.*



has been typical of many American industries. The people of New England formed the original labor force, but before 1850 this was insufficient to man the mills. Skilled English textile workers and then increasing waves of French Canadians from Quebec and of southern Europeans, especially Portuguese and Azore Islanders, came to the mill towns of New England to find employment.

Similar to the textile industry in Lancashire, New England's cotton manufacturing has declined. Here, too, the early advantages are outweighed by more satisfactory economic conditions in other areas and by grandsonitis, or the inbred ideas of management that have failed to change in response to new conditions in business, and other psychological disadvantages of being born rich. Find a firm 75 years old and bearing the name of the founder. Are his grandsons managing it? Rarely.

World War I provided temporary relief, and in 1924 New England mills still contained about half the nation's textile spindles and utilized two fifths of our mill-consumed cotton. Then began the wholesale liquidations which have continued, with only a slight reprieve during World War II. In 1954 New England processed only 6% of the mill consumption of cotton on 14% of the nation's active cotton spindles (see Fig. 537).

The new industry in the South. Unlike old England, New England's competition came from another area within the same country. This was the southern Appalachian Piedmont between the Fall Line and the mountains. In this crescent-shaped area from southern Virginia to northern Alabama, rapid growth of cotton manufacturing began in the 1880's. Water-power sites along the Fall Line and in the Piedmont attracted some mills, but steam and then electric power soon freed the industry from this locational restriction. Local supplies of cotton were also an early advantage, particularly for mills selling goods on southern markets. However, northern markets continued to be important, and the Piedmont mills were increasingly dependent on cotton from southwestern and western states, so that local raw material has been of minor significance.

Lower labor costs have been the major advantage for the mills in this area. The Appalachian Mountain district had a white population, dense in relation to the resources and therefore with inadequate opportunity for employment, so that wages were much lower than in the North. When the cotton mills gave an opportunity for profitable employment these mountain people and the families of sharecroppers migrated in large numbers to the mills just as the people of Quebec and Europe migrated to the mills of New England. They worked longer hours for lower wages, were less unionized and less protected by labor legislation than the textile operatives in the North. Up-to-date machinery was more efficient, especially after the development of the automatic loom in the 1890's, which greatly reduced weaving costs and was more rapidly adopted in the South. All these factors added up to lower wage costs with equal if not greater labor productivity.

Other advantages aiding in the supremacy of the southern Appalachians in United States

cotton manufacturing are lower living costs, cheap coal and electric power, lower taxes, and the great desire of many southern communities for industry, resulting in various sorts of local inducement. In recent years the expanding southern market for manufactured goods has been an additional advantage.

Between 1880 and the mid-1920's cotton spindles in the cotton-producing states increased from ½ million to 18 million. Since then the number has remained relatively constant, while the collapse of the industry in New England has accounted for most of the national decline in cotton-mill equipment (see Fig. 537). Southern mills began with the production of the coarser types of yarn and cloth, such as duck, drills, and sheeting. As the industry expanded and the southern workers developed greater skill, supremacy was established in successively higher qualities of goods until, at present, the finest of cottons can be successfully produced in the "new" area. Greenville and Spartanburg, S. C., are the major centers, but the small town with one or two mills is the more common locational type in the southern Piedmont.

Cotton manufacture in other sections of United States. The Middle Atlantic states have had a cotton-textile history similar to that of New England. Early mills were located on water-power privileges in the upper Hudson Valley and along the Fall Line in Pennsylvania and Maryland. Philadelphia was the major center, where skilled English textile workers helped to make possible the establishment of branches of the industry which had not previously flourished in America. The manufacture of tapestries and chenilles as well as dyeing and finishing were particularly important. But these specialties, too, have decreased in importance in the face of competition from southern manufacturers together with that from man-made textile fibers.

West of the Alleghenies cotton manufacturing is unimportant and not increasing very rapidly, despite considerable efforts to develop it in the western Cotton Belt.[8] The southern Piedmont remains the most economic area of production. Then, too, the production of cotton textiles has expanded but little, and the number of spindles has declined since 1924. Such conditions do not stimulate the development of new areas of manufacturing.

The extension of cotton manufacturing. The developments in our Appalachian Piedmont have been duplicated in other areas. Many countries have established cotton mills, often under the protection of tariffs, and in some it has developed into an export industry. This is suggested by the sevenfold increase in the number of spindles among the "all other" countries in Table 30:1. In this category, Brazil, Canada, and Mexico, each with more than 1 million spindles (1953), lead a considerable number of cotton-manufacturing countries scattered in many parts of the world.

India-Pakistan. However, the most important developments have taken place in India, China, and Japan, whose dense populations provide an industrious labor supply and a large market. India, once the major export market for Britain, was the first to develop a cotton-mill industry. Bombay, a major port city with much available capital, was the initial center. Indian and imported cotton with imported coal were used to manufacture yarn, at first for the export trade chiefly to Japan and China.

The industry in Bombay expanded with the development of weaving mills and the growing importance of the Indian market for yarn and cloth. It is still India's major center, producing about 30% of India's cotton-mill products. However, expansion has long been more rapid in other locations. Ahmedabad, in the fertile Gugarat cotton district, rivals Bombay as a mill center, and since 1900, a number of smaller centers have developed in the interior cotton-producing districts, particularly the Deccan and southern India, and also in centers such as Cawnpore and Calcutta in the populous Ganges Valley. Local raw materials, nearby markets, cheaper labor, and (sometimes) available hydroelectric power are the

[8] In 1953 Texas had 229 and Mississippi 118 thousand cotton spindles.

familiar factors influencing this development.[9]

India is a striking illustration of a fundamental characteristic of industrialization in Oriental countries—the continued importance of small-scale and hand methods of production in the face of the technical superiority of a growing factory industry. In 1948 over 500,000 workers employed in 400 cotton mills operated 10 million spindles, 265,000 power looms, and produced 4 billion yards of cloth. However, the *Indian Yearbook* for 1947 estimated that 10 million persons were dependent in some measure upon the hand-loom manufacture, which produced nearly 2 billion yards of cloth on 2.5 million hand looms. By these figures each hand loom produced only one twentieth as much as a power loom, but several times as many people were connected with this less-productive method of manufacture. Such a situation can exist only in an area with a large and poor population.

The partition of India and Pakistan has affected the cotton-textile industry, although not as drastically as jute. Indian cotton mills have become more dependent upon imported raw materials and export markets—circumstances that may again place Bombay at some advantage. Pakistan is expanding her textile industry in the effort to supply her own cloth requirements and utilize a portion of her large surplus of raw cotton.

China. Like India, China has a large market and is an important producer of cotton, much of which is utilized in a widespread handicraft industry. Shanghai, for nearly a century a foreign-controlled port, developed into China's dominant cotton-mill center. Like Bombay, it utilized imported coal with domestic and some imported cotton, first for the production of yarn, then increasingly in the manufacture of cloth. But its product went mainly to internal markets. Unlike India, the rival centers were chiefly ports with nearby cotton-producing areas—Tientsin, Tsingtao, and Hankow being the most important. These did not seriously threaten the dominance of Shanghai, which in 1938 contained over 60% of China's 4.3 million cotton-mill spindles, and few mills were developed in the inland cotton-producing areas.

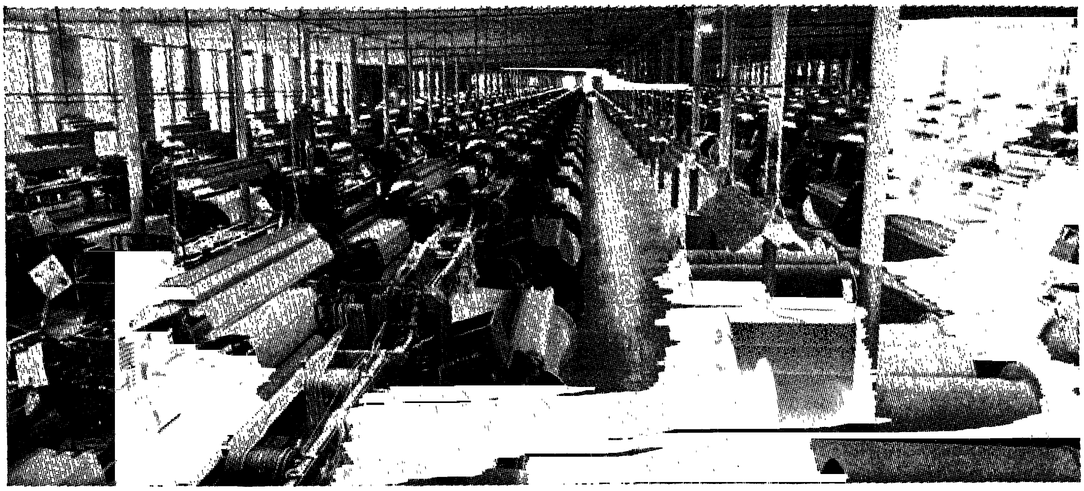
This picture has been somewhat changed by the disorganization of the war years as well as the efforts of the Communist Chinese to build new mills in Manchuria and North China. However, the basic patterns remain as before, with Shanghai the leading center and the need for imported cotton to mix with the domestic supply in the effort to meet the demands of the large Chinese market for cotton goods.

Japan. Japan provides one of the best examples of the role of the cotton mill in a developing industrial society. With her small amount of land and dense population, she of necessity turned to manufacturing. Cotton textiles, made from imported raw materials, became Japan's major industry and first ranking export by the 1930's. At first dependent upon foreign machinery and technicians, the Japanese quickly developed their own technology. After World War I she was able to equip her own expanding mills and to supply machinery, capital, and technical personnel to the growing industry in China. In Japan, Osaka became the leading center, particularly for the large spinning mills, to which girls from the agricultural districts were brought in large numbers. They provided a docile but quickly trained labor force, working long hours for low wages.[10] Here was the major factor in Japan's increasing dominance of the export market, especially in cheaper goods for Asiatic and African countries.

By 1923 Japan had passed the United States

[9] These developments have been compared to the locational shifts in the United States. Although the older areas, Bombay City and Ahmedabad, have declined but little, their costs are higher and they specialize in the better quality products. See O. H. K. Spate, *India and Pakistan,* E. P. Dutton & Co., New York, 1953, pp. 280–283.

[10] In the mid-1930's it was estimated that labor cost per unit of product in Japan was not more than one fourth of that in any major textile-producing country in Europe. International Labor Office, *The World Textile Industry, Economic and Social Problems,* Geneva, 1937, Vol. 1, p. 215.



The longest loom room in New England. If one thread breaks, the loom stops. One operative for many looms. ***Crompton & Knowles Loom Works, Worcester, Mass., Amoskeag Mills, Albany, N.Y.***

in the value of cotton goods exported, and was second only to the United Kingdom. In the 1930's Japan came to lead all nations in the total value of cotton-textile exports. Indeed, in 1938 Great Britain imported £400,390 worth of Japanese cotton goods, and faced increasing competition in foreign markets.

Despite its continued importance, Japan's cotton-textile industry was overshadowed by the more rapid expansion in manufacture of metals, machinery, and chemicals after 1930. During World War II nearly 80% of Japan's cotton spindles were destroyed by bombing or scrapped to provide metal and factory space for war industries. However, the 2.2 million spindles of 1946 have grown to 7.5 million in 1953—most of which are modern and efficient. Japan is again an exporter of cotton cloth but the amount has been only 40 to 50% of the prewar average.

Cotton and cotton goods in commerce. Cotton, the greatest staple of the world's clothing, gives rise to much commerce. Formerly, no important cotton-manufacturing country except the United States produced enough cotton for its own use, and, consequently, we sent cotton to nearly all the manufacturing countries. Even the United States imported foreign cottons because they possessed qualities not found in American cottons.

The increasing difficulties of world trade in the years since World War I have brought profound changes in cotton culture as well as cotton manufacturing. New areas for both have become significant and change the world picture of the industry. The United States has lost its dominance in the export of raw cotton. England and, more recently, Japan have similarly declined in importance as exporters of cotton manufactures. With cotton-growing areas widespread and cotton manufacturing a relatively easy industry to develop, it is not surprising that many nations strive for self-sufficiency—a tendency that will bring future changes in the international trade of both raw and manufactured cotton.[11]

2. THE WOOL-MANUFACTURING INDUSTRY

Woolens, worsted, and shoddy. The world's wool clip is only 10% to 15% as large as the cotton crop on a quantity basis. Also, as we have seen in Chapter 29, wool fiber is a more complex raw material than cotton and is produced under conditions making major increases in its supply most difficult. Consequently, the modern wool-manufacturing in-

[11] Robson (*op. cit.*, p. 121) estimates that since 1910–13 world trade in raw cotton has declined from 62% of mill consumption to 40%, while corresponding figures for cotton goods show a decline from 28% to 13%.

dustry is much smaller and less widely spread than is cotton, although of major importance in certain areas.

A further difference lies in the fact that the wool-manufacturing industry has two separate and distinct branches in addition to the scouring operation that removes grease and dirt from raw wool. "Woolen" fabric is loosely woven from yarns that have been given little twist. After weaving woolen cloth is "fulled," a process in which the cloth is beaten to give a felting effect, and finally the fibers are pulled up by being gently combed with teasels so that the cloth has a uniform, smooth, almost furry appearance. This process adds strength to the woolen cloth and may totally obscure the pattern of weaving. "Worsted" yarn is smoother, more even in texture, and has more twist than "woolen" yarn. In the worsted process, cleaned and carded wool is then combed to separate out the longer fibers and lay them parallel to form wool "tops," which are then spun on worsted spindles. The remaining shorter fibers (noils) are used in the woolen process. Worsted fabrics are tightly woven and the pattern of the weave is clearly discernible. The difference between these separate fabrics is thus chiefly the result of the use of longer staple wool and more elaborate preparation and spinning processes in the manufacture of worsted yarns. Worsted fabrics have become increasingly popular with the trend toward lighter, more highly styled clothing in recent years.

"Shoddy" is thick, warm cloth made of remanufactured wool fibers obtained by tearing up tailor's clippings and woolen rags, mixing them with new wools, and weaving all into a warm cheap cloth. World production of "reclaimed" wool is about one fifth as great as that of new wool (cleaned basis).

European wool manufacture. Europe remains dominant in the woolen and worsted industry, with about two thirds of the world's mill capacity and production of woolen and worsted fabrics. The United States (now the world's leading single producer) and Japan are the other important producing countries. But there have not been the important locational shifts in this industry comparable to those which have characterized the cotton-textile industry during the past half-century. Three major factors largely account for this locational stability: (1) wool manufacture is more complicated and requires greater skill than does cotton; (2) the product is more expensive and is consumed mostly in North America and Europe, where winters are cold and people are relatively prosperous; and (3) most of the world's wool is produced in areas of sparse population and limited market for manufactured woolens and, in addition, the historic methods of transporting and marketing this complex raw material give an advantage to the established marketing and manufacturing centers. The five wool exporters of the Southern Hemisphere produce half of the world's wool but manufacture less than 5% of the wool textiles.

TABLE 30:2. Production of Wool Fabrics, 1949
(millions of meters)

United States	379
Europe	
France	264
United Kingdom	258
U. S. S. R.	162
Germany, West	142
Other Europe[a]	372
Total Europe	1198
Japan[b]	29
5 other countries[c]	110
World total[d]	1716

a Twelve countries.
b Japan's production in 1938 was 222 million and by 1950 had risen to 66 million meters.
c Turkey, India, Australia, New Zealand, and Canada.
d World production of cotton fabrics in 1949 was 23,883 million meters in comparison to the above total for wool fabrics.
Source: Compiled from W. S. and E. S. Woytinsky, *World Population and Production—Trends and Outlook,* Twentieth Century Fund, 1953, pp. 1070, 1085.

In the Middle Ages Flanders was the great leader in wool manufacturing. The fertile, well-tilled Rhine delta gave a good food supply for villages of manufacturing people, and canals, rivers, land routes, and sea routes made easy the distribution of the goods produced largely from imported wool, then the staple export of England. The English kings intro-

duced Flemish weavers into England during the eleventh, fourteenth, and fifteenth centuries, but for a long time unfinished English woolen cloth went to Flanders to be finished and dyed. This practice seems to have ended about 1650, and England surpassed her old teacher Flanders in quality and quantity of output.

In eighteenth-century Europe, and colonial America as well, the water-powered fulling mill to process hand-spun and hand-woven woolen cloth was nearly as common as the water-powered grist mill to grind local grain. The Industrial Revolution, therefore, burst in upon a long-established, widely dispersed, and sometimes highly developed woolen handicraft industry. The adoption of the new technology was delayed, however, and it was not until after 1850 that woolen and worsted manufacture became primarily a factory enterprise. This was in contrast to the cotton-mill industry—virtually a new-born child of the Industrial Revolution. Even today handicraft and semihandicraft production of wool products is significant in various parts of Europe, although it is of a different character and relatively less important than the Oriental handicraft production of cotton goods.

England is still among the leading countries, particularly in the production of quality fabrics, but it has never been so dominant in the production of woolens and worsteds as it was in the nineteenth-century cotton industry. The West Riding of Yorkshire is to the wool manufacture what Lancashire is to cotton. Here, just across the Pennines from Lancashire, are located nine tenths of Britain's worsted mills and two thirds of the woolen branch. Within the West Riding there is also a local geographic separation, with the manufacture of worsteds concentrated in the northwestern and woolens in the southeastern parts of this western section of Yorkshire. Soft water and water power from the Pennine moors, coal from the Yorkshire field, and iron for the Yorkshire metal and machinery industry were the local advantages upon which an industrious and hard-working population built a major industry. The West Riding towns of Bradford, Leeds, and Huddersfield are known wherever fine manufactures of wool are bought and sold. The presence of small and scattered concentrations, especially of the woolen branch, in Scotland, Lancashire, and southwestern England represent survivals of the more widespread distribution of the handicraft era.[12]

Upon the Continent there is really but one wool district, extending from Milan to the North Sea and the English Channel, including Paris and Berlin. This takes in the valleys of the upper Danube, the Elbe, the Rhine, the Po, the Seine, and includes the densely peopled manufacturing region of Czechoslovakia, Austria, West Germany, Switzerland, northern Italy, northeastern France, Holland, and Belgium. Before World War II this continental wool industry was newest and most progressive in Germany, which led other nations in her deliberate and skillful promotion of the industry. Silesia, Saxony, and Westphalia, three German coal districts, have been important wool centers.

Wool manufacturing in the United States. During the eighteenth and early nineteenth centuries, small woolen mills were established over almost all the settled country. As was the case in England, this dispersed geographic pattern was changed by the factory production of wool textiles which grew in importance under tariff protection beginning in 1828. Today, although small factories are found in many states, the bulk of the industry is located east of the Appalachians and north of Maryland. Philadelphia is the leading single center, especially in the manufacture of carpets, but the concentration of mills in numerous cities and towns in the area tributary to Boston makes New England dominant in this branch of the textile industry. The high degree of skill required in wool manufacturing, the dominance of Boston as a wool mar-

[12] Wilfred Smith (*op. cit.*, pp. 108–114, 414–461) contains the best account of the historic development and the contemporary economic geography of the British woolen and worsted industry.

keting and scouring center, and nearness to northern markets have enabled New England to retain about three fifths of the national wool-manufacturing capacity, in striking contrast to the collapse of its cotton-textile industry. The Middle Atlantic states account for nearly a quarter of the industry (see Table 30:3).

TABLE 30:3. Woolen and Worsted Machinery in Place in the United States, 1949
(figures in 1000's)

	Woolen spindles	Worsted spindles	Woolen and worsted looms	Carpet and rug looms
New England	750	1267	21.6	.9
Middle Atlantic	340	414	8.1	3.9
South	165	96	4.7	..
All other states	169	60	3.1	.4
Total	1424	1837	37.5	5.2

Source: U. S. Bureau of the Census, *Facts for Industry*, Series: M15H-09 Supplement, August 14, 1951.

However, a "shift to the south" has begun. Between 1939 and 1949 the number of installed woolen and worsted looms declined by 25% in New England, while in 10 southern states there was a 50% increase. As with the cotton industry, the South's major woolen area is the Piedmont from Virginia to northern Alabama, where in 1939 there were 29 plants. Between 1940 and 1951, 30 more were established (9 woolen and 23 worsted mills). Twenty-five of these were branches of northern firms, several of which have closed their mills in New England.

This expansion was particularly rapid during the postwar period when no new mills were built in New England. As with cotton, the South's major competitive advantage is in lower labor costs for wool manufacturing. The southern manufacturer obtains most of his raw material (scoured wool, tops, and yarn) from the Northeast and similarly ships his product mainly to northern markets. However, the higher transport costs involved are outweighed by the savings in labor and other cost items.[13] Here we have another indication of the growing maturity of a "new" industrial area as well as the problems of an "old" area in meeting interregional competition.

Carpets. Wool is important in carpet manufacture, although the better carpets, such as Wilton, Axminster, and even Brussels, have a strong web of jute or hemp into which the wool is woven. Synthetic fibers and even cotton are being increasingly used, especially in the production of broadlooms. The resulting carpeting is much less expensive than all-wool broadloom.

The first carpet mill was established in 1791 in Philadelphia, which has long been noted as the great carpet-manufacturing center of the United States. In 1947 Pennsylvania had 40 of the country's 95 mills, New England 23, and New York 14. But New York has several of the largest mills in the world, so that it outranks Pennsylvania in production and employment. All our carpet wool is imported duty-free since our domestic wool is mostly of apparel grade. China was formerly an important source, but in recent years Argentina has supplied about half of our requirements with most of the rest from the countries of southwestern Asia from Turkey to India.

From this area also come Turkish and Persian rugs, the best in the world, produced in the oases and villages of the remote interior of Asia. They are the product of pasture and flocks highly condensed by the slow, laborious hand labor of a domestic manufacture, which, it should be noted, is turning out a better and more highly prized product than the Western factories with their mechanically perfect goods. These valuable products are sometimes borne by caravan (now often by truck) to the larger cities or to the seacoast, where Turkish merchants or the rug buyers from Europe or the United States bargain for them. Before 1915 Constantinople was the center of this trade, which now has been rather widely scattered among various Eastern cities.

[13] James A. Morris, *Woolen and Worsted Manufacturing in the Southern Piedmont*, 1952, pp. 82, 83, 92 ff. See also the more general analysis by the same author, "Cotton and Wool Textiles—Case Studies in Industrial Migration," *The Journal of Industrial Economics*, November 1953, pp. 65–83.

In the wool textile districts of western Europe, carpet manufacturing is an old and important industry, producing for the local market and for export to many parts of the world. "Oriental" rugs manufactured in England or Germany sometimes appear in the bazaars of the Middle East. Let the buyer beware!

3. THE MANUFACTURE OF SILK AND SYNTHETIC TEXTILES

Silk manufacturing in the Old World. Silk manufacturing, always a luxury industry with small physical output, has undergone drastic changes resulting from the invasion of synthetic fibers. The weaving of silk fabrics developed in the raw-silk areas of China and spread, in ancient times, to Japan. Handmade fabrics of most excellent quality have long been exported from these countries. In the modern period, however, their export of raw silk has been much more important (see Chapter 29), partly as a result of tariffs levied on silk manufactures by importing countries.

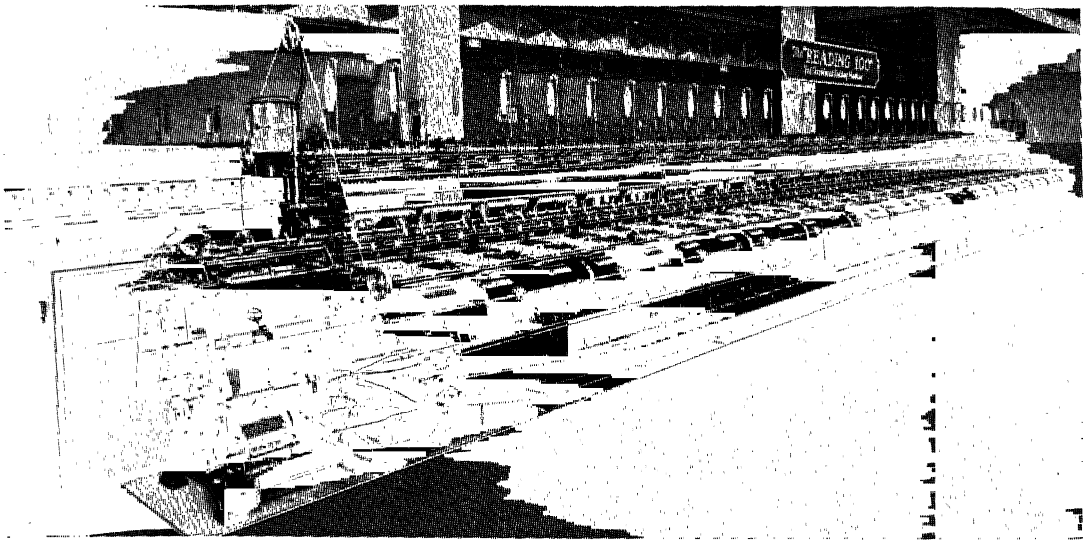
Silk manufacture spread to Europe and, as in the Orient, reached its highest development in the raw-silk areas that supplied both material and labor. During the nineteenth century France was the leading silk-manufacturing nation, with Lyons the chief center for the industry. Located in the Rhone Valley, one of the great thoroughfares of Europe, the silk growers and weavers of Lyons found it easy to supplement the local supply of raw silk with imports from Italy, the Levant, and the Orient.[14] Labor was drawn from the mountain valleys of the Alps on the east and the Central Massif on the west, whose streams were later a source of hydroelectric power.

For decades Lyons specialized in the production of figured brocades of great beauty, woven on the Jacquard loom, a local invention, and worn wherever Parisian fashions were followed. Around the turn of the century these manufacturers were slow to adapt their product to the rising demand for lighter, less-durable, but more highly styled fabrics, and the prosperity of Lyons waned. However, the shift was eventually made, and Lyons remains important in silk manufacturing and as a marketing center for the silk mills which have spread to nearby towns in the Rhone and its tributary valleys.

In the Po Plain of northern Italy, Milan holds a position similar to that of Lyons in silk manufacturing and as a center for mills scattered in the small towns of the Alpine foothills. The Swiss silk manufacturers are scattered through many towns, but Zurich is the chief center for the manufacture of cloth. About the middle of the nineteenth century the Swiss developed a power loom for silk weaving which, together with their policy of pleasing their foreign customers, enabled them to cut into the export market dominated by the French. Germany also developed a silk industry, located in the south and west. Among the textile countries of Europe, Great Britain is the least important in silk manufacturing. Its silk industry was virtually destroyed by a flood of imports, mostly from France, when tariff protection was removed in 1860.

Silk and rayon weaving in the United States. This situation was reversed in the United States, where import duties, imposed on silk manufactures, formed the basis for a rapid expansion of the industry beginning about 1870. Raw silk came from Japan and unemployed silk workers from England. The first important center was Paterson, N. J., a city with adequate water power, supplies of soft water, and close proximity to New York, the major market both for raw silk and the finished product. Silk manufacturing is comparatively light work, and the percentage of women operatives in silk mills is higher than in most other branches of textile manufacture. It has therefore been termed a "parasitic" industry in that it favors location near to other

[14] Several long filaments of raw silk must be twisted together (thrown) to form a yarn sufficiently strong and uniform for weaving. Shorter filaments, from damaged cocoons for example, are made into "spun" silk yarn on spinning machines. Comparable distinctions between the processes of throwing, weaving, and spinning are also found in the rayon industry.



Pennsylvania knitting machine, 55 ft. long, 198,000 parts, 16 tons, 50 full-fashioned stockings per hour. One person can tend 2 machines. ***F. K. Fogelman***

industries which employ large numbers of men so that the wives and daughters of the workmen provide a labor supply for the silk mills. Paterson, with its important metal-fabricating and metallurgical industries, provided such a situation and was for years our leading silk center. However, similar conditions were to be found in Pennsylvania, and the silk industry grew more rapidly in and near the coal-mining towns of Scranton and Wilkes-Barre, the cement-manufacturing towns of Allentown and Easton, the agricultural implement-manufacturing town of York, as well as in the coal and iron towns of western Pennsylvania. First silk throwing and then weaving developed in these areas and there was an actual decline in Paterson after 1910. The industry also spread to New England and to the southern Piedmont, but New Jersey and Pennsylvania remained the major areas.

With the rise of synthetic fibers during the past quarter century, silk manufacture has virtually lost its identity as a separate industry, and its locational pattern has been greatly changed. Production of silk fabrics in the United States declined during the 1930's, virtually ceased during World War II, and has since revived to less than one tenth of the 1929 level. Meanwhile, rayon and, more recently, nylon fabrics have left silk far behind (see Table 30:4).

Rayon and nylon have also displaced silk in the hosiery industry, its most important outlet in the prewar period, as well as in the weaving of "mixed" fabrics. In the face of these developments, many silk weavers converted their machinery to handle synthetic yarns and found that five to eight times as much rayon fabric could be produced with the same number of employees.[15] In addition, new rayon-weaving mills were built and cotton

TABLE 30:4. United States Production of Broad-woven Fabrics[a]
(millions of linear yards)

	Cotton	Woolen and worsted	Silk	Rayon and acetate	Other synthetics
1929 ...	8,239	324	505	107	...
1939 ...	8,287	360	69	1341	...
1944 ...	9,547	526	2	1602	82
1953 ...	10,203	338	38	1903	464

a Excluding tire fabrics.
Source: U. S. Department of Commerce, *Facts for Industry*, Series M15C-03, July 28, 1954, p. 2.

[15] This is because the greater uniformity and strength of synthetic yarn makes it possible to operate the looms at higher speeds, and, in addition, a single weaver can tend up to 40 rayon looms but only about 6 silk looms.

mills converted to the processing of synthetic fibers. This has meant a greater importance for the southern Piedmont and New England as centers for an expanded silk and rayon industry of which silk manufacture now forms but a small part.

Similar developments have occurred in other silk-manufacturing countries. In Japan, France, Switzerland, and Great Britain rayon weaving has expanded greatly, and there have also been substantial declines (1951 compared with 1938) both in exports of silk fabrics and in domestic consumption of silk. Only Italy has maintained its prewar levels. There seems little likelihood of a revival of silk manufacture in the Western nations. Instead there may be a tendency to depend more upon import of silk fabrics from the raw-silk-producing areas to meet the limited demand. Costs of production are lower, especially in China and Japan. Dyeing and finishing, the chief basis for style in silk fabrics, can be done near the style centers as has long been the case with the famous Liberty silks which the British have made from imported fabrics.

In recent years the United States has imported more silk fabric than we have produced, but our total import of silk in various forms is only about 10% of the peak imports of the late 1920's. This indicates clearly the limits which the world-wide production of synthetic fibers and fabrics imposes upon the production of raw silk and its manufacture.

4. THE MANUFACTURE OF LINEN

The linen industry. The manufacture of flax into linen lost out in the competition with other fibers whose production and manufacture benefited more from the revolutions in industry and agriculture during the last century and a half. However, Northern Ireland (especially near Belfast) and the south of Scotland, which a century ago grew flax and manufactured it on hand looms, now are centers of the world's finest factory-operated linen manufactures. Next to agriculture, the manufacture of linen is the most important industry in Northern Ireland, employing directly or indirectly one sixth of the working population. Two thirds of the workers are women, so that the linen industry forms a natural complement to Belfast's other major industry, shipbuilding, with its predominantly male labor force. This industry goes back to the seventeenth-century influx of Huguenot and Scottish hand spinners and weavers. With the advent of the factory system, Northern Ireland lost out to Great Britain in the manufacture of woolen and cotton textiles, but developed a dominance in linen which it retains today. Domestic flax is supplemented by imports, primarily from Belgium but also from eastern Europe. Linen, Northern Ireland's leading export, is shipped all over the world where fine fabrics are appreciated, the United States taking the largest share.[16]

Linen manufacturing is also found in several textile districts on the Continent, especially in Germany, Czechoslovakia, France, and Belgium. Local materials, long tradition, and cheap labor provide a basis for the industry. These are not found in the United States where linen manufacture is relatively unimportant. Our linen imports, however, have declined. Here we see some results of the war between the laboratory (rayon, etc.) and the field.

5. COMMERCIAL CLOTHING MANUFACTURE

Late development as a factory industry. The manufacture of clothing remained a hand operation, on a made-to-measure basis, and often conducted in the home, long after the factory system had become dominant in the cotton textile, steel, and various other industries. The supplying of sailor's clothing was the start of the ready-made clothing industry in such port cities as New York, New Bedford, and Boston. Following the development of the sewing machine in the 1850's and the

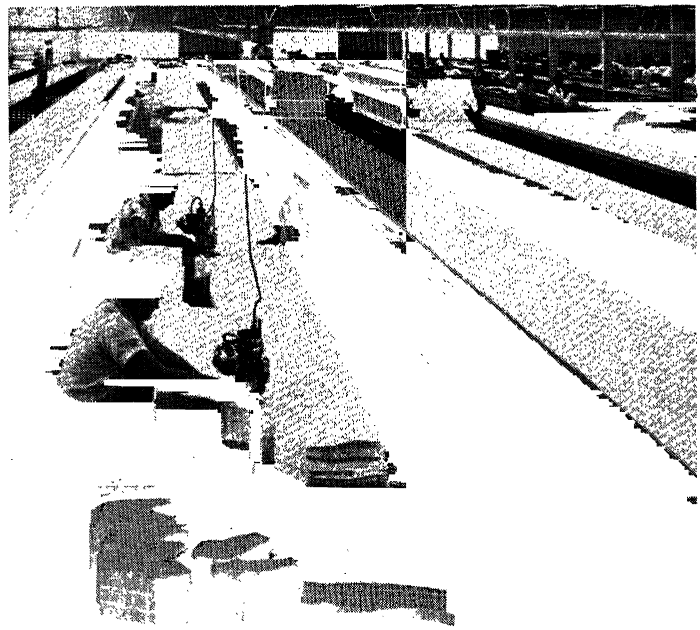
[16] See T. W. Freeman, *Ireland, Its Physical, Historical, Social and Economic Geography,* E. P. Dutton & Co., New York, 1950, pp. 230–234.

Civil War, with its demand for millions of garments, the production of ready-made men's and, to a lesser degree, women's clothing became important in a number of cities. Great abuses arose through the "sweat-shop" system of home work in crowded tenements or in depressing workrooms, often at very low wages. Legislation, aided by the application of electric power to the constantly improving machinery, has controlled the major abuses and paved the way for dominance of the factory. However, it was not until after World War I that factory production assumed major importance in the women's dress industry.

Why it is a city industry. Clothing manufacture belongs to large cities because of the double advantage of nearness to market and to labor. Style is the master for many branches of the clothing industry. Few industries demand such a close connection between the manufacturer and the "buyer." The wholesale or retail-store buyer wishes to select his stock from the offerings of a number of manufacturers—just as the housewife likes to "shop" several stores in the selection of a hat, a pair of shoes, or a dress. To meet this desire of the buyer, the manufacturer seeks a location close to the center of the market where he can make quick delivery and where he can also keep abreast of the latest style and other developments.

The large city also provides the necessary labor supply. Pressing equipment, electric sewing machines (with more than 200 specialized types), and cutters are in universal use. Nevertheless, the operator's skill is important to the quality, and his manual dexterity to the quantity, of his output. The production of higher-priced garments still requires much hand work. So a large and varied supply of labor is vital and made more so by the seasonal nature of production in the clothing industries.

Other locational characteristics of a clothing "factory" make it possible for it to respond to the labor-market pull of the urban center. It needs no large, specialized buildings, so ma-



With electric cutter, operator cuts 100 garments at a sweep. Electric sewing machine? Whiz! Zip! ***Eastman Machine Co., Buffalo, N. Y.***

chines and workers may be crowded into the multiple-story, high-rent loft buildings which characterize the garment districts in many cities. Also cloth, the major raw material, is of relatively high value, is easily transported from the various textile centers, and, therefore, has little influence on the location of the clothing industry.

The dominance of New York. New York, the nation's major city, its leading wholesale and retail market, and dominant style center, epitomizes these locational advantages which make it the leading clothing-manufacturing center by a wide margin. It was the chief port-of-entry for the late nineteenth-century flood of immigrants from eastern and southern Europe, whose descendants still constitute the major element in the industry's labor force. In 1947 nearly 350,000 workers, 35% of the national total in the "apparel and related industries," were employed within the New York metropolitan area,

while Chicago (41,000 workers) was a poor second. New York City clothing manufacturers produce over a third (by value) of the nation's apparel goods, with these percentages ranging from 80 for women's "unit-priced" dresses to under 20 for the less highly styled "dozen-priced" dresses, shirts, and work clothes.

Within New York City about 200,000 clothing workers are employed in the 150-acre garment district in mid-town Manhattan, roughly bounded by Broadway, Eighth Avenue, 20th Street, and 40th Street. Within the district there is even further localization with, for example, manufacturers of popular-priced "dresses," medium-priced "frocks," and better-priced "gowns" concentrating in their respective subdistricts.

New York's clothing industry is thus a striking example of the attractive force of locational concentration (see Chapter 16). Especially in the dress industry, the great variety of styles plus the whim of Dame Fashion mean that the individual production unit must remain small—a "factory" with 30 employees being typical. Since the size of operations can seldom be increased, production economies must be gained by specialization and subdivision of function. This is easier when there is a large number of firms in the same locality. The individual manufacturer can restrict his product within narrow limits as to price, style, and size. There is often a further subdivision of processes with cutting, sewing, and pressing carried on in different establishments. In an urban location the manufacturer can obtain quick delivery from cloth merchants; he can rent or buy machinery and have it repaired by specialists; he can purchase buttons and other accessories from their manufacturers; he can tap a trained labor supply and even temporarily hire a designer to turn out a new "number." It is in this manner that clustered location of establishments allows the small manufacturer to gain some of the advantages of mass production and division of labor which he cannot achieve by increasing the scale of his own operation.

The clothing industry in the rest of the United States. Outside New York the clothing industry is located principally in cities but also in towns and even villages. In 1947, 11 other metropolitan districts each had more than 10,000 production workers in their apparel factories. Among these are old and established commercial-manufacturing centers: Boston, Philadelphia, Chicago, Cleveland, Baltimore, and St. Louis, whose garment districts, in many ways similar to New York's, emphasize the production of men's and the less highly styled women's clothing. Rochester, N. Y., smaller than the others, specializes in men's suits and overcoats for a wide market. Los Angeles has risen rapidly to third place among clothing centers as a result of its growing population, together with the style influence generated by Hollywood and the rapid expansion of the sports-wear industry.

The three other leading metropolitan areas are not major cities. Two, Allentown–Bethlehem–Easton and Scranton–Wilkes-Barre, are in the coal–cement–steel area of northeastern Pennsylvania. The clothing factory, like the silk mill, is something of a parasite in this situation (see above, p. 544). The third, Fall River–New Bedford, is in southern Massachusetts, where the garment industry was drawn to the unemployed labor and low rents in the vacant mills resulting from the collapse of the cotton industry. All three areas are close enough to New York to gain some of its marketing advantages, and yet avoid the high costs of operation in mid-town Manhattan. This is an example of the long-established and well-recognized tendency for the less-highly styled garment industries to locate in suburban areas and also in outlying cities and towns. This centrifugal movement is found in most of the older garment districts, but despite it, the city-centers are still the dominant locations.

Finally, several of the clothing industries are widely spread throughout the country in towns and smaller cities. This is particularly true for the industries producing shirts, work clothing, hosiery, and the cheapest women's

wear.[17] For these style is unimportant, the necessary machines can easily be transported and set up in almost any type of building, and the flexibility of truck transport aids in the assembly of raw materials and the distribution of finished products. Consequently, they are among the most mobile of our industries, seeking locations where labor costs and rents are low.

Clothing manufacture in the Old World. The use of ready-made clothing is less general in Europe than in the United States, chiefly because the lower wages make it less necessary to use machinery. However, the leading cities of Europe, with their garment districts for factory-made clothing, occupy positions in their respective countries similar to that of New York. A major difference is that the sweat shop as well as the custom tailor are relatively more important. A considerable export of the cheaper ready-made clothing goes to the far corners of the world from Britain, Germany, and France. It is interesting to note that as Japan's industrial evolution advances along Western lines, a factory-made clothing industry develops there also.

The fashion industry. Paris, long the fashion center of the world, has developed a specialized industry that utilizes both the artistic qualities of the French and its own fame as the world's pleasure capital. Women and clothing manufacturers the world over wait eagerly upon the dictates of the Paris designers to learn whether skirts will be long or short or whether the silhouette will be rounded or flat.[18] But this industry's major export is fashion rather than garments, for only a few can afford the luxury of a Paris label. Instead, soon after the Paris "showings," reasonable facsimiles by American manufacturers will be available as high-priced gowns in the salons of the exclusive Fifth Avenue shops and also as inexpensive dresses on the racks of the less-pretentious establishments along 14th Street—likewise and almost simultaneously in Chicago, San Francisco, Sauk Center, and Main Street of a thousand towns.

Textile competition. The competition among fibers (see Chapter 29) is carried over into the competition among the manufacturing industries which process the raw materials. Here, as has been noted, there is not only the competition among *industries* but also among *countries* and manufacturing *areas*. In this complex of economic and geographic relationships the processing of man-made fibers seems destined to be increasingly important. However, the textile and clothing industries as a group will remain a major branch of world manufacturing and probably increase in importance in newly industrialized areas.

---

[17] In the late 1930's it was estimated that 40% of the employees in the men's cotton garment industry (shirts, pants, work clothing) worked in towns with population of 25,000 or less and only 16% in cities of over 1 million. U. S. Bureau of Labor Statistics, *Bulletin 719,* "Earnings and Hours in the Men's Cotton Garment Industries," p. 2.

[18] Such questions receive careful consideration and much publicity as, for example, on the cover and eight full pages of the magazine *Life,* September 6, 1954.

31· Bases of Trade

Trade arises because people or peoples have different products. If a people cannot produce something, they must buy it or do without. Since human wants are almost limitless in kind and quantity, trade is deeply based in man's nature. It is also deeply based in geographic conditions, because different areas differ so greatly in the possibilities of production.

Products of peoples, regions, nations differ for three main reasons: (1) Peoples differ in their cultures and their skills. (2) Peoples differ in the stage of their industrial development. (3) Peoples have effective access to different resources.

1. DIFFERENCES IN PEOPLES

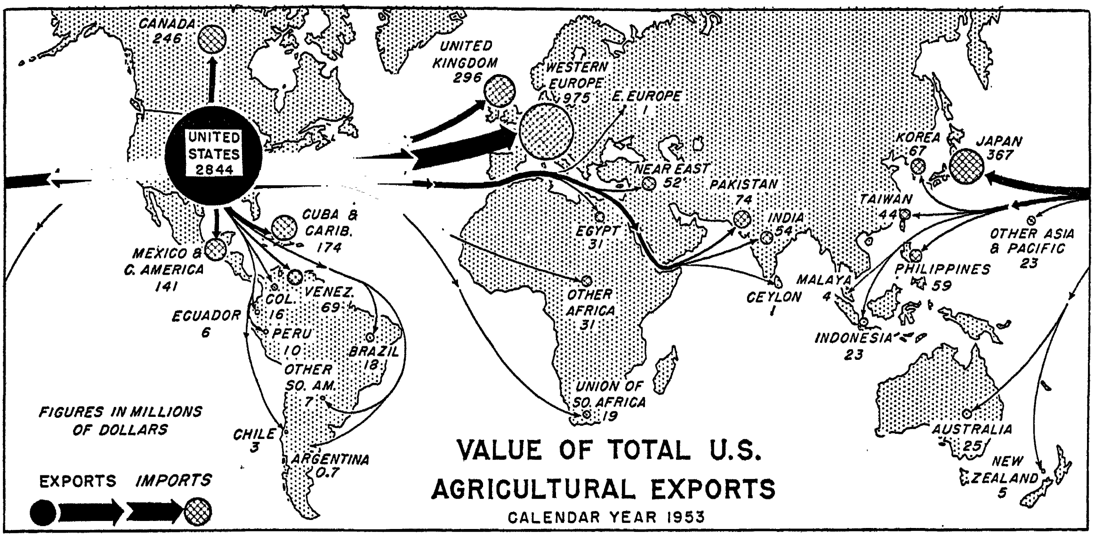
Native cultures. For 40 generations or more, millions of families in China, Japan, India, Iraq, and Iran, and some other countries have passed the techniques and habits of making things from father to son and mother to daughter. The older folk have taught the younger ones to make rugs, silverware, goldware, bronzeware, brassware, pottery, porcelain; products of silk, cotton, leather, and lacquer. Every globe-trotter brings back some of these precious products of the ancestral skill and the artistic instinct and symbolism of peoples steeped in an old culture that has ideas, points of view, and standards of propriety and beauty, which differ from our own.

The Navajo Indian blanket and the Indian pottery of our Southwest and Mexico are examples of this class of difference that makes trade.

The North American or South American woman who leaves Paris, the great fashion center of the Western World, without some pieces of Paris feminine finery is completely dead broke or dead. Anyone who has spent a few days on the streets in each of half a dozen capitals of Europe will probably agree that the French people have a sense of taste in women's dress that differs from that of other nations. The export of Paris goods is the export of French taste, plus skill, but basically it is *taste,* a personal quality of the designers and artisans. It is kept alive and developed by many schools for the cultivation of this talent.

It appears that this trade, essentially *art,* has an enduring future—enduring, but small, especially small in proportion to the mass-production stuff. Most of the Japanese and Chinese and other artistic Asiatics will continue to go over to mass production as many now are doing. But it is quite possible that a peaceful year A.D. 2000, if we can achieve it, may see more Oriental art exported than did the year 1900 or any normal year since. In percentage it may be but a scrap. Some of these people will probably continue their arts, but it is not likely that other peoples will take the trouble to learn them.

Science as a basis of difference in production. Another point where national difference has made trade is in another form of skill—namely, scientific knowledge put into



From the country of big fields to lands of many people. ***U. S. Department of Agriculture***

factory production. From 1860–1914 the two great English universities, Oxford and Cambridge, were stressing the classics and calling science "the stinks" because of the now well-known odor of a chemical laboratory. Higher education in the United States of that day took its predominating flavor from the mother country.

During this period the German universities were stressing chemistry, physics, geology, and psychology. A dozen German universities were turning out doctors of philosophy in these sciences, especially chemistry. They entered the factories, and Germany promptly led the world in making and exporting chemicals.

The international goal of science. Before the days of the Iron Curtain, science had the goal of being international. This concept went so far that at the opening of this century you could have a semester course of lectures in a German university by a world-famed scientist for $2.50 American money. The German universities fairly swarmed with Americans, Latin Americans, Greeks, Poles, Hungarians, Czechs, Russians, Japanese, and some Chinese. Learning was almost free.

Young Americans and British went home with Ph. D. degrees in chemistry to help start home industries and college laboratories. This production, based on scientific knowledge, has a greater tendency to spread than that based on artistic instinct. Much German export of chemicals to the United States declined because German-taught chemists went to work at transplanting the industry in the United States. There the seed of chemical knowledge fell upon good ground, but knowledge alone does not make an industry.

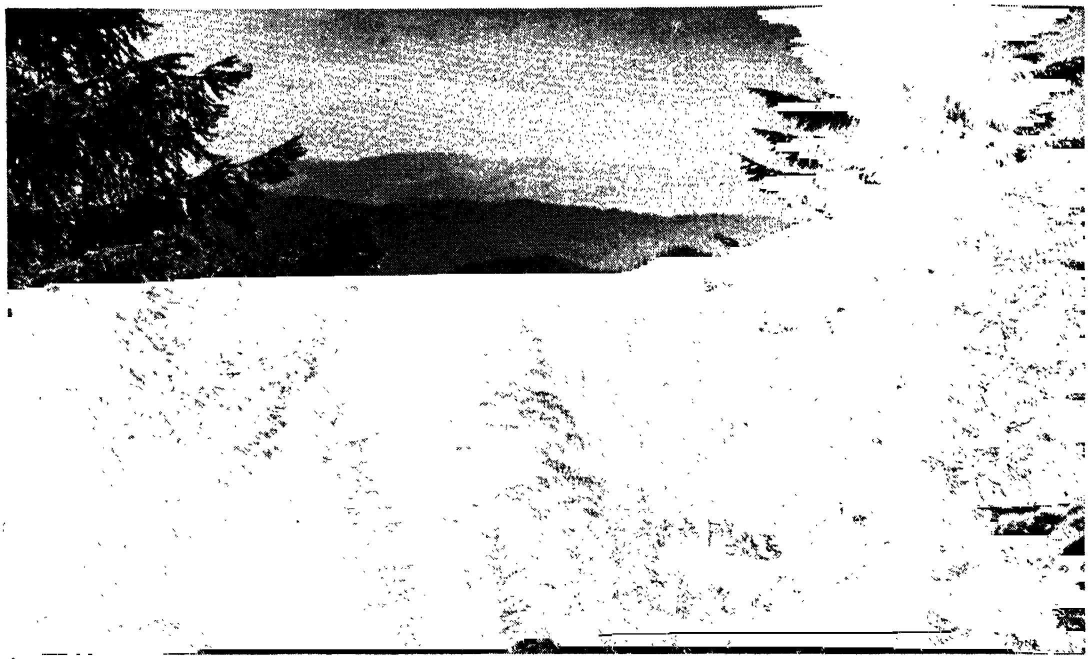
German chemistry and scientific industry did not take root much south of the Rio Grande and the Alps. It was copied a little in Japan, but most of the world gets most of its chemicals, especially the finer ones, from the lands of know-how beside the North Atlantic—from the center of chemical industry in the lands of Western civilization.

Scientific knowledge requires a complex seedbed to transplant and grow into an industry.

2. DIFFERENCE IN STAGE OF INDUSTRIAL DEVELOPMENT

The greatest trade of the last 100 years was between regions of dense population and regions of scanty population. This relationship is more clearly stated if we consider the available resources per person rather than of numbers of people per unit of area.

Lands with scanty population and many resources export products in which raw ma-



U. S. Pacific Coast forest. Lumber to trade for nursery trees and bulbs. ***West Coast Lumberman's Association***

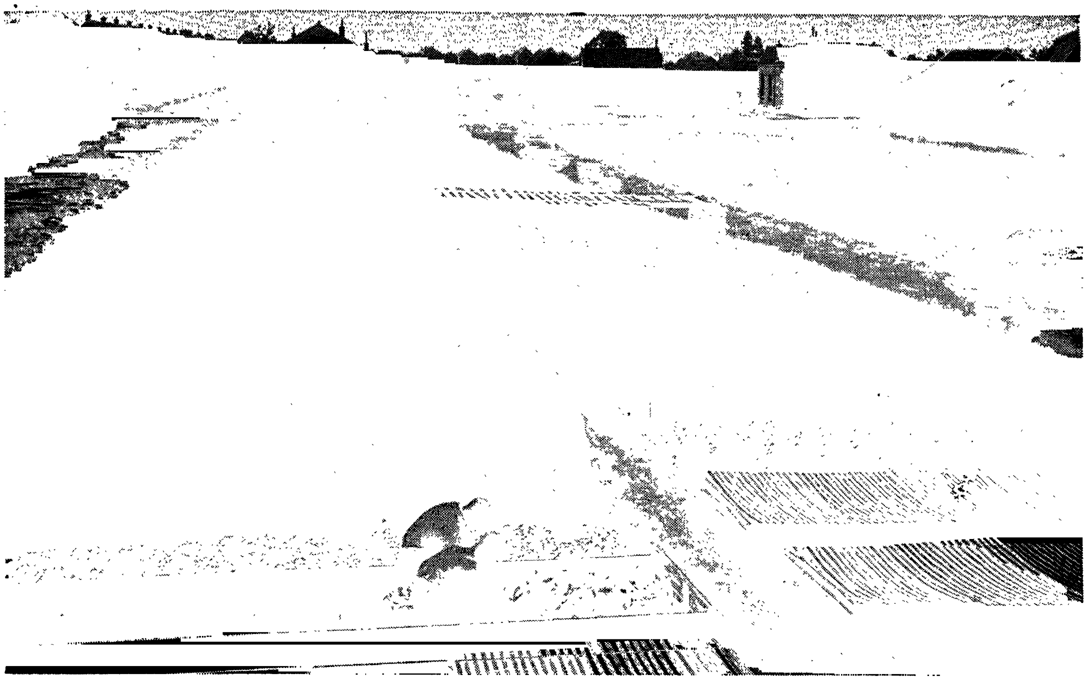
terial tends to outrank labor as a part of the value. Many people in a land of few resources must export products in which the labor element of the cost is large.

In the last century the people of European races left densely populated Europe and moved to new lands. There they felled the forests for quick lumbering, skinned the prairies with one-crop farming of grain or cotton, grabbed the surface minerals. The frontiersmen did these reckless things in all continents, even in northern Japan, in the process of getting something quickly to export and pay for the many factory products that frontiersmen had to have.

The frontiersman's produce of grain and raw material went first and chiefly to densely peopled Europe, where man has been long on the land, where population had become so dense that man had to intensify industry or go hungry or get out. This trade between scanty population and dense population, between the undeveloped and long-developed regions, shows interesting contrasts. Lumber from the frontier or cold forests where timber land has almost no value is exchanged for plant products of Holland, where rich alluvium is worth more than $1000 an acre. From this land of gardens the Dutch nurseryman sends out little trees by the million and bulbs by the ton. We see bales of cotton going to Europe from the wide expanses of our South and coming back as lace or fine cotton cloth. U. S. copper goes to Europe and comes back as part of scientific equipment.

American cotton from our broad tractored acres goes to France and Spain, and wine and olive oil return. Oil and wine are products of tedious hand labor often on terraced hillsides —land of high price per acre despite the difficulty of tilling it.

The trade in metals between the lands of different stages of industrial development shows the United States sending assembly-line autos to Europe and the rest of the world, and getting back finely fabricated metal in the form of watches, scientific instruments, intricate machinery—some of it made by hand. Some products of Swedish steel are worth more than their weight in gold. The United States has not produced one little packet of my lady's sewing needles. All are European,



Dutch nursery. Trees to trade for lumber. *Homestead Nurseries, H. G. Benckhuysen*

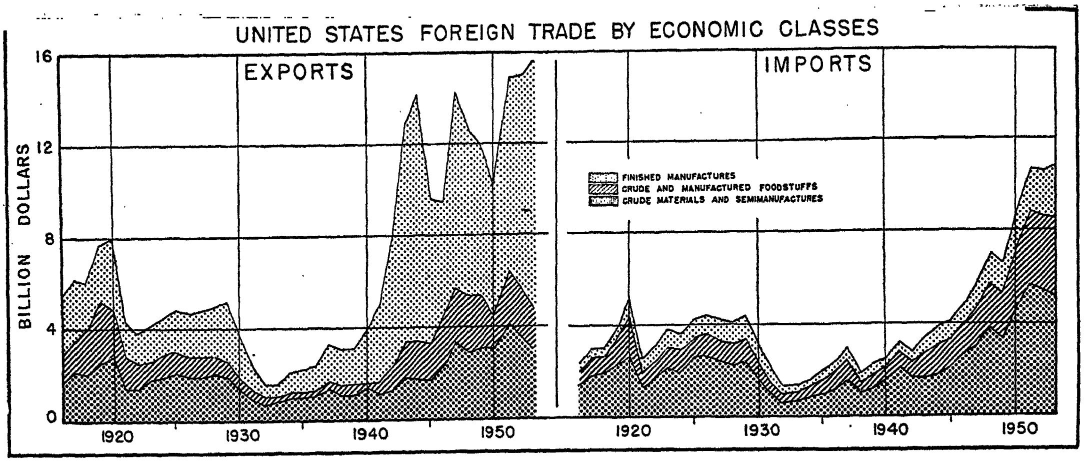
chiefly British. We also see this idea in a reversed example as we import iron ore from the wilds of Labrador, Venezuela, and Liberia and sell the peoples of those countries machinery, structural steel, and metal roofing.

The migration of industry. This trade tends to disappear through the spread of industry. England started the machine industry. It moved to New England. New England soon had a frontier market across the Appalachians and in the South. New England now sees its cotton mills moving to the South, its machinery mills moving across the Alleghenies, where Chicago, Cincinnati, St. Louis, and 40 Corn Belt towns are making machinery—mostly heavy machinery. New England is making mighty efforts to hold on by making devices in which material is small and Yankee skill and ingenuity are large.

Industry migrates, but there are limits to the extent of migration. Industries differ in their ability to move. The Machine Age may be said to have begun with spinning and weaving. These machines have had nearly two centuries of use, trial, study, experiment, and perfection. They are marvelous in their approach to the automatic, and to the machine-makers' ideal—a machine that any fool can use and no fool can break.

An enterprising person in Venezuela or Uruguay can buy automatic looms in Europe or the United States. A local agent may stock parts. The enterpriser can import yarn, or a neighbor may make it with bought spinning machines. The weaver has the simple job of operating automatic looms to make cloth of simple kind. Thus, Brazil is almost self-sufficient in textiles and exports several times as much as she imports. But machinery is heavy in Brazilian imports and does not appear in her exports. It is likely to be many years before anyone pretends to manufacture an automobile anywhere between the Rio Grande and Cape Horn; and when this car is announced, the place of origin of the greater number of its parts will be an interesting study. Indeed, the textile industry can move much sooner, much farther, and to many more places than can the factory that makes typewriters, adding machines, or automobiles.

The mass-production machine industry needs a great home market to enable it to



Note the changing proportions of manufactures and foodstuffs. ***U. S. Statistical Abstract, 1954***

have enough business to use *mass production.* That industrial fact is a great limitation to the spread of manufacturing. To see the point sharply, compare it with the spread of wheat growing to other continents where American and European tools and machines are used.

3. DIFFERENCES IN AVAILABLE MATERIAL RESOURCES

The idea of natural resources brings us right down to the geographic earth—physical material, climate and the possibilities it holds out to us if we take advantage of its possibilities and avoid its impossibilities.

Nature had a large deck of cards marked as follows: good coal, medium coal, poor coal, peat; rich soil, medium soil, poor soil, clay soil, sandy soil, rocky soil; and so on through a hundred kinds and qualities of natural resources. She dealt these cards out to the nations in such a way that there is a tremendous difference in the things that come to man's hand to aid him in producing useful commodities in the different countries and regions of the world. Difference in resources in the different countries makes trade inevitable, if there is to be anything approaching equality of consumption and comfort among the peoples.

Minerals make trade. The mysterious gods of geology were not democrats. They did not treat the lands equally. They had stupendous favors—oil, gold, iron, copper, aluminum, and other minerals—that they deposited in various places, both good and bad, convenient and remote. Man is forced to go to the very gates of Hades (climatically) to get the gold of New Guinea and Guiana, and to the mosquito-ridden and blizzard-swept wastes of Labrador or Sweden for iron, and to the equally cold and unpleasant shores of Great Bear Lake for gold and uranium.

Minerals give us the greatest riches. They give the heaviest trade—the ore car, the ore train, the ore boat, the tank car, the tank truck, the tank steamer, the pipeline, the coal car. Wheat and cotton, the great staples of the last century, make but pigmy traffic as compared with the gigantic tonnage of coal, ore, and oil. Minerals cause feverish settlements—the gold rush town; the boom town that rises over the week end on prairie where oil is struck. Minerals make feverish diplomacy, too, and the constant menace of war.

Short life of mineral trade. As human history goes, trade in most minerals is short-lived in any place, except for some quarries of common stone. There is an indefinite amount of aluminum in common clay, but we cannot get it yet. There is infinite (almost) magnesium in sea water. Otherwise, the metals and the fuels are very definitely, even painfully, limited if we take any long view. Many deposits are so limited in quantity that the period between "boom and bust" is often short, even in the terms of one life, and the final end a hole in the ground. Spend two days

coastal plains and the rest of the United States. Similar examples can be found in many countries.

Tobacco takes up what the soil contains, and many soils give well-recognized flavors to the tobaccos that grow on them. This is especially true of a certain area in Cuba. The tobacco produced upon it gives the Havana cigar its reputation, and gives the land a high sales value.

Trade based on soil differences seems permanent and destined to grow with the fuller utilization of the earth as home of man.

4. DIFFERENCES IN CLIMATE MAKE TRADE

You can move to another climate realm by a 5- or 10-mile climb up 3000 or 4000 feet to a mountain valley or plateau. The climatic difference at the two ends of your short journey is a basis for trade. Consider the trade in lettuce and cabbage. These succulents require cool temperature to make good heads. Lettuce thrives at 8000-foot altitudes in Colorado and comes down in July and August to lowland market. Likewise cabbage goes to the Gulf lowland from 3000-foot elevations in southern Appalachia. At 2500-foot elevations in southern California apple orchards look down on orange orchards on warmer land 2000 feet below.

For a larger trade examine any well-developed country with a 300-mile stretch north and south and you will find the warmer parts sending fresh early garden produce, fruits, and flowers to the cooler parts. The French and Italian Riviera, Dalmatia, the Crimea, a little corner south of the eastern Caucasus, and the warm southwestern corner of Britain are examples which Japan can duplicate. In the United States California, Florida, and the Gulf Coast regions have similar export trade with longer haul.

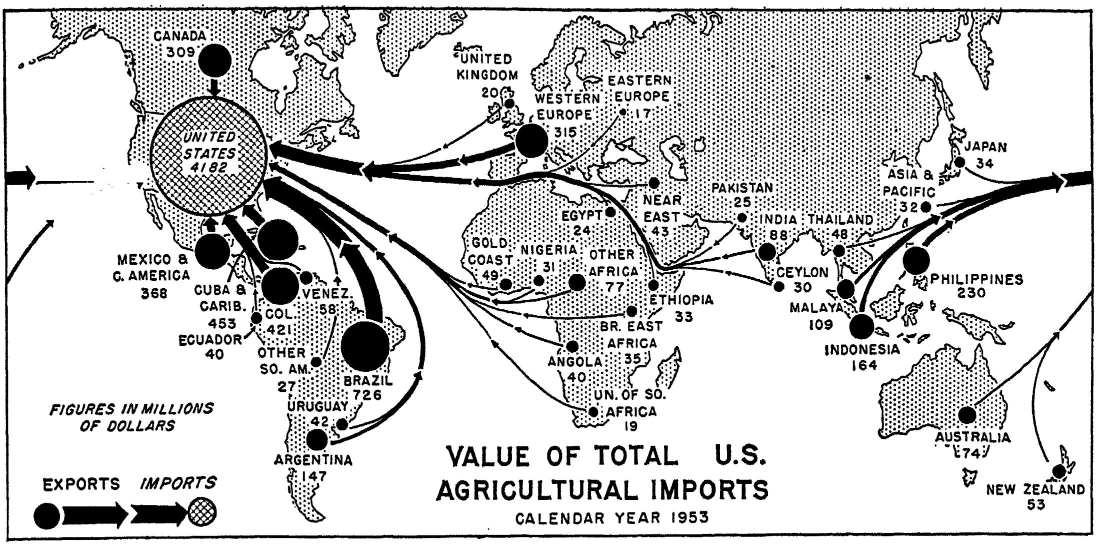
Wheat, rye, barley, and white potatoes from cool lands have a real and permanent basis for enduring exchange with cotton and sweet potatoes. Apple, peach, and American grapes grow where winter freezes hard and will continue to be exchanged for the orange, cotton, tea, and early vegetables of the warmer lands.

It was interesting to the senior author to stand beside a pile of mahogany logs on a dock in Hispaniola and watch the pine lumber from Mobile come out of a ship alongside while local mahogany went into another hatch—soft wood for hard. Different climates make different kinds of lumber.

Tropical climate makes enduring trade. The hot land with its palm and the cold land with its pine show the basis for a great and growing trade that promises permanence. The frostless tropic zone that girdles the world has a long list of monopolies owing to dependable high temperature—banana, coffee, cacao, palm oil, copra, babassu, rubber, mahogany, and many more new crops yet to be developed. This trade of tropical products in exchange for thousands of factory products and a few cool-land foods has been a conspicuous development of the miraculous century of steam transport that has remade world trade. It has firm basis for growth and permanence.

The differences in moisture. The humid lands and the arid lands are given to us by differences in moisture. There is natural trade between these types. In all continents having deserts and humid lands, there is a band of sheep and cattle ranges between the lands of farms and desert. Here a sparse population has two or three products to sell; it must buy most of its food from more humid farm lands and must secure from the manufacturing towns all the other products that are to be purchased in the store.

In the irrigated oases of the cool arid lands, sugar beets and alfalfa give a money crop and rich stock feed for the animals from the adjacent steppe. This increases the animal products that the ranchmen of Eurasia and the Americas send to the more humid districts, which can with ease produce other articles for exchange. This exchange of animal products for grain and manufactures is world-wide and seems to be as enduring as the variation in rainfall, the distribution of people, and the ability to transport with ease.



Climate* is the dominating factor—sugar, coffee, bananas, cacao, spices, rubber, tropical fibers. Compare values. *U. S. Department of Agriculture

The Mediterranean climate favors the production of fruits, and modern transport gave these areas a quick boom bordering on natural monopoly in much of this new trade. The increase of this trade has been even greater than that in grain and meat. It is here to stay. It has spread to every continent, and it advances with the advancing stages of population density and maturity of economic development.

5. SOCIAL CONDITIONS AND POLITICS—THE THINGS THAT MAN DOES THROUGH GOVERNMENT

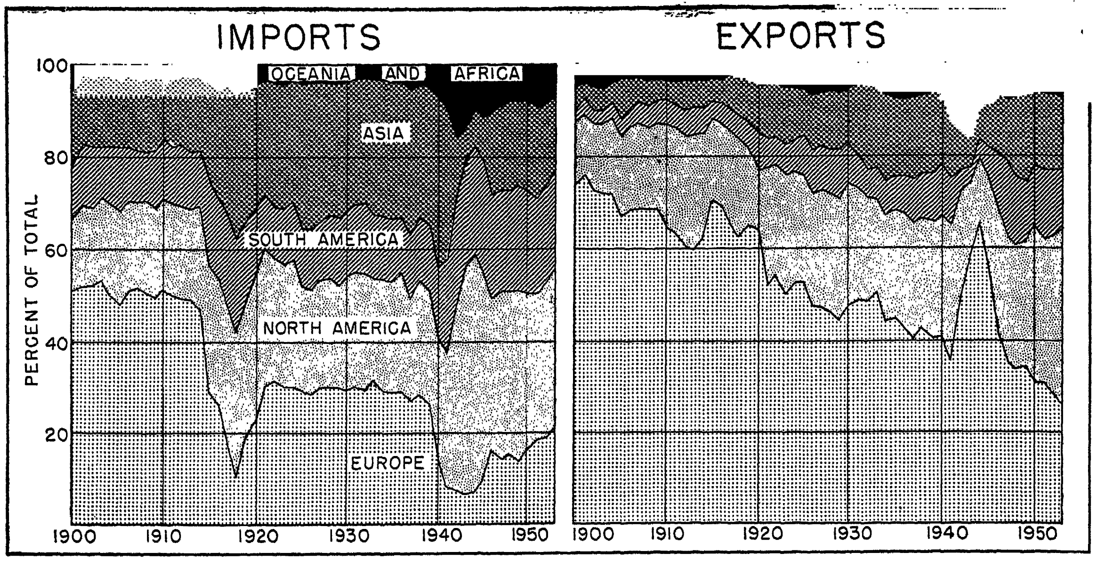
Relative importance of basic forces. We have presented the three main bases or forces that cause trade. We had to present them one at a time. But it is true that no one factor can act alone. Each industrial situation shows several factors, although it is often conspicuously visible that one factor outweighs the others.

We have also called attention to factors that lie in the nature of earth and to some that lie in the nature of man, and point toward continuity and probable increase in influence; also to some that indicate decline in the force and results of the various factors. There remains one more group of human influences that interfere with the normal workings of Nature and free man to produce or hinder trade—social and political conditions. These often outweigh and suppress the resource situation.

Is business safe? The answer to this question tells much about the spread of industry and the development of trade. In Chapter 1 we told how unstable government or dishonest government makes it impossible for the people of some underdeveloped countries to secure capital from the people of other countries. Therefore industry cannot start. Honesty and stability are about as important for home industry as for the foreigner who might come and start something.

A large part of the world's people live under such conditions of society and government that large-scale property for scientific operation of industry is not safe, whether owned by home folk or by foreigners. For those peoples trade must be at a low level while such conditions prevail—and that may mean decades or generations, despite the desires of intelligent, progressive minorities; but remember Turkey.

Economic independence. Many countries feel the need to have more manufacturing industries. This urge may be based on actual need, and it is often pushed on by pride or military ambition. In recent decades Canada, Australia, South Africa, Argentina, Brazil, Chile, Mexico, and other countries have resorted to high tariffs, subsidies, and other



Foreign trade, origins and destinations. See what World War I and World War II did to European trade. Explain shifting shares.

Comment: Export figures 1950-53 somewhat altered by the fact that "basic continent data excludes, for security reasons, exports of Special Category commodities, representing from 6.2% of total exports in 1950 to 26.4% in 1953." ***U. S. Statistical Abstract, 1954, p. 922***

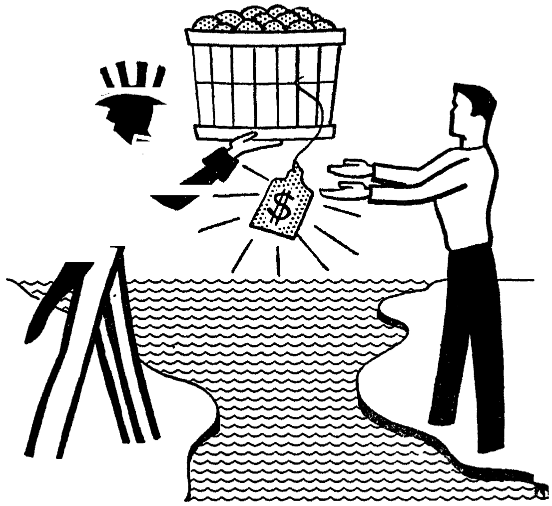
devices to foster the growth of domestic manufacturing and also to increase exports. In many cases high-cost industries based upon mediocre resources have arisen under tariff protection, and consumers have had to pay higher prices for manufactures produced at home. It does not appear to be well known by lawmakers that tariffs, import quotas, and other barriers which curtail a nation's imports also bring about a corresponding reduction of its exports. No nation can sell abroad unless it will buy, and thus let the foreigner pay.

Our government spends millions to subsidize steamship lines to carry exports. We send a small, but well-trained army of consuls abroad to study trade conditions and send home reports telling us how to capture trade. Then with the other hand we raise a tariff wall that checks the foreigner when he tries to sell us something to get dollars to buy our produce. The only way he can get dollars is to sell *his produce* to *us* or some other nation. It does not appear to be rational, but a locality or an industrial group—a pressure group—pushes for better income for *its group* only. The national interest may be another matter.

There is no reason to doubt that tariffs have checked the amount of international trade by stimulating the growth of industries, chiefly manufacturing, in many countries which are not able to start or keep these industries without the aid the subsidy tariff gives.

Man-made barriers to trade have become so numerous since World War I that the world community of nations now resembles a checkerboard of high-walled estates akin to those of the Feudal Ages. The continued growth of international trade in spite of artificial barriers proves that international trade is both necessary and profitable. No nation on earth can hope to achieve complete self-sufficiency. No amount of political interference can eliminate the economic interdependence even of the United States, much less the many underdeveloped countries that form our world today. Indeed, interdependence of some kinds is increasing, due to the increasing variety of raw materials needed to make some of the newer products, especially metalwork. Our host of delightful new gadgets rouses almost universal wants in a hundred lands that cannot supply the wants by home industry. We need but mention radio, auto, and airplane and their accessories.

Price support by government action. Tariffs usually raise the price, give the producer a better income, and cause industry to spread to new lands. Exactly the same result may follow the support of price by government, but there is one conspicuous difference; example, cotton. The U. S. government raised the price of cotton in the attempt to give the farmer and the farm laborer a better share of the national income. The higher price encouraged Brazil and other countries to grow cotton, and the U. S. cotton export dropped.



Too true, says Europe: goods out, money in. Uncle Sam now has buried in Kentucky (Fort Knox) a very large share of world's gold. *U. S. Department of Agriculture*

6. LOCATION FOR TRADE AND AMOUNT OF TRADE

The location of a country helps or hinders trade. A glance at a map of the world's land hemisphere shows that Great Britain is in the center. Hence, Britain and nearby lands have the advantage of the shortest distance to the bulk of the world's land area and machine-using man (see Fig. 571). This location is excellent for trade. It faces the New World across the narrow North Atlantic and lies at the doorstep of the most populous, productive, and progressive part of Europe. Likewise, the location of the United States between the densely populated areas of western Europe and eastern Asia may prove to be a major factor in the future growth of U. S. overseas trade, if we wish to have it. You will see more clearly the value of North Atlantic location if you get a globe and contemplate the trade value of the location of New Zealand, which happens to be almost exactly at the antipodes from Britain.

7. VOLUME OF TRADE AND TRADE STATISTICS

Size of country and volume of foreign trade. Foreign trade, depending thus upon natural laws, modified by man's aid and interferences, is of varying importance in different countries. It has a general tendency to be least important in countries with a wide variety of natural resources and most important in countries having a small variety of resources. China peacefully and successfully ignored the foreign world for many centuries, because she was a world within herself, reaching on the south to the latitude of Havana, on the north to the latitude of Newfoundland, producing cotton, rice and wheat; and reaching westward across semiarid and arid pastures to the desert and semiarid pastures of Central Asia. The world could give her nothing that she did not produce. She therefore scorned the world.

In the late eighteenth century the British government sent a mission to China seeking to establish trade relations. In a half-page reply the Chinese Emperor of that day has left on record a classic example of contempt and scorn. The workmanship of his people was better than the British, and he sent the British home with a swift and stinging philosophical kick. But along came science, with petroleum, cheap machine-made cotton cloth, modern machine manufactures, and new machinery. These have tempted the Chinese to buy. Although their foreign trade was recently estimated at \$2 per person, it would have been much greater but for the political chaos of recent decades. In these years, however, many Chinese had set out to adopt Western economic methods.

Foreign trade per capita. How big is a country? Has it few or varied resources? These factors influence the need for trade and the amount per capita.

Small countries with almost no variety in climate and small variety in resources—such as Switzerland, Belgium and Denmark—have a relatively enormous foreign trade. So does England. So would New England if it were an independent country and we had the figures of commerce that cross her southern and western boundaries. But most of New England trade is with other states of the Union, and disappears without statistical record in our vast domestic commerce, which is many times as great as our foreign commerce. If all Europe were but two nations, corresponding to the United States and Canada, most of the astonishingly vast commerce that was recorded in pre-World War II days would not have entered the statistical record. And if the United States were chopped into a dozen independent pieces and kept its present trade (which would be impossible), the figures of quantity would be stupendous.

The Falkland Islanders are sometimes mentioned as an extreme example of heavy per-capita trade. Their islands, 4618 square miles, are east of Magellan Strait where the wind blows so hard that no tree can live, but grass and sheep do thrive. The 2280 Falklanders have 618,000 sheep and a whaling station. They catch whales in the seas to the southward. In a recent year they sold, per capita, $828 worth of wool and $5100 worth of whale products. These ranchers and whalers imported accordingly, and this included just about everything you could think of.

At the same time the Soviet Union is reported to have $4 per capita and the United States $142. We made a table of per-capita trade but concluded that it confused about as much as it showed so we do not include it. Too many factors enter to permit an attempt at explanation here, and perhaps it would not have high value even if it were fully explained.

Trade means movement of goods—transport—bundles on man's back, on his head, on pack animal, wheelbarrow, cart, wagon, truck, train, boat, barge, ship, pipeline, airplane.

Transport from producer to consumer also involves assembling, packing, loading, forwarding, storing, unpacking, buying, selling, dividing, and dispersing locally or to distant places. In addition to vehicles, this work requires freight stations, docks, wharves, warehouses, salesrooms, counting rooms, service industries, and workers by tens or hundreds or thousands. All this work makes towns and cities—trade centers. The trade center is the natural subject of the next chapter.

32· The Trade Center and Its Development

1. THE DEVELOPMENT OF COMMERCIAL CENTERS

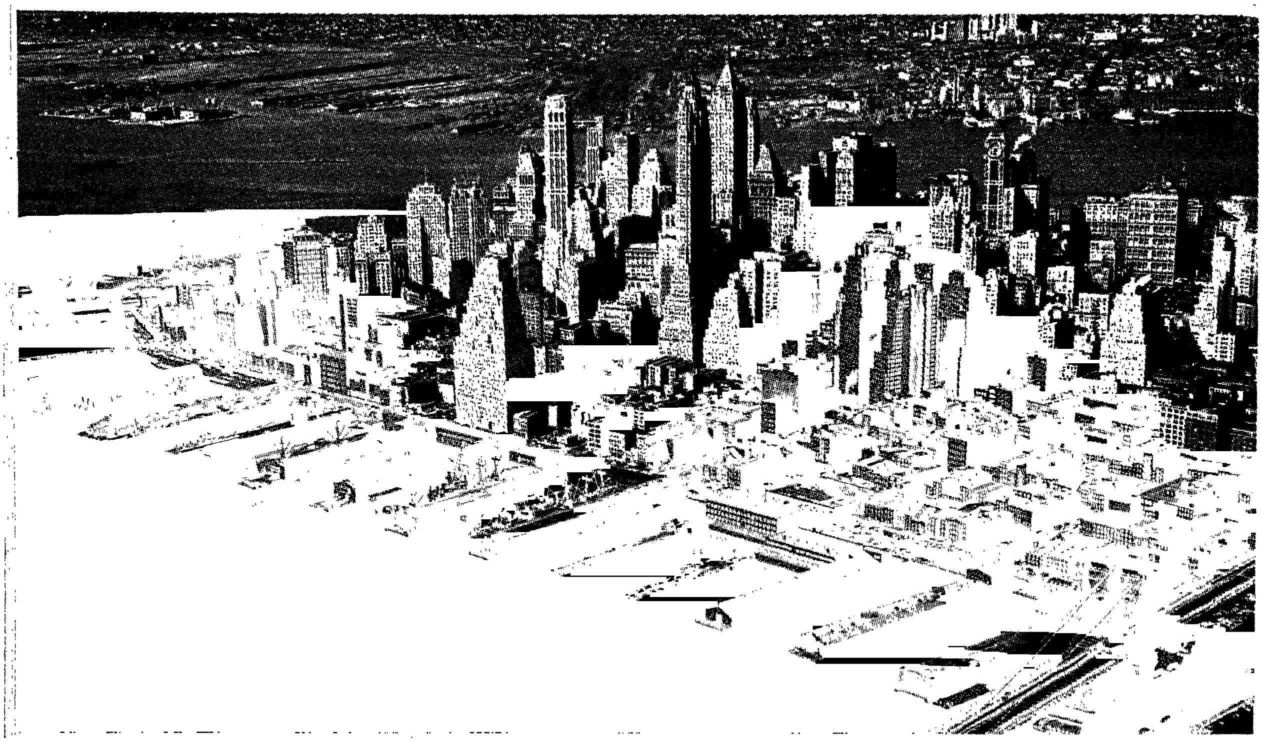
The origin of towns and cities. The great currents of international trade usually pass from one city to another, and the same condition is also true of domestic trade. Cities and trade are continually exerting reflex influence, the one upon the other. To truly understand the large commercial movements, we must understand the economic functions and origins of the city.

The origin of the town goes back into the early history of the human race—before the days of the first permanent settlements and the first regular trade. There are places in Asia where people still congregate for a temporary residence and period of trade—a temporary town, whose people disperse to the four corners of the compass when the market adjourns. The present-day metropolis is but a town grown permanent through regular trade and grown large through much trade, and the same laws govern its growth and push it from its village beginning to its metropolitan ending.

The beginning of commerce is a barter between two individuals. Each has a surplus of a specific article, and each finds advantage in the exchange of that surplus. The most complex phases of present-day commerce are but the outgrowths of this simple exchange of goods, complicated by the numberless wants of man, the variety in natural resources, the world-wide distribution of industry, and the myriad complexities of invention and production.

The rise from barter to money and the expansion of trade to international proportions have produced many institutions. First and most fundamental among these is the *trade center*, or collecting and distributing center. Granted riches and neighbors, trading man soon develops so many wants that it becomes inconvenient to visit individually the various people with whom he wishes to trade, and some common meeting place is the result. Many previously isolated individuals now have a place for common activity; some of them a place for common residence; and a market place or fair, a village, or a town comes slowly into being. It is interesting to note in this connection that in many European cities this plot of ground where the primeval trading took place continues to this day as a market square—as in Antwerp, Brussels, and many other cities now grown great. It is also to be found in many a small European country town.

The normal trading town is, therefore, manifestly and most naturally located in some spot easy of access, some spot with a superiority of access usually due to geographic causes.



A trade center—Lower Manhattan Island, New York, with Brooklyn Bridge in foreground. Financial center and Wall Street are in center of pile. More people on skyscraper square mile by day than any other on earth. ***Port of New York Authority***

If the superiority of access is sufficiently great, the settlement around this market place becomes a city with international trade, for the market village and the metropolis are alike products of economic forces that differ only in degree, not in kind.

The kinds of cities. In examining the causes for the growth of cities, one should note the distinction between industrial and commercial causes—between industrial and commercial cities. Examination shows that most cities have both commerce and manufacturing in some degree. The mere numbers of people inevitably produce a certain minimum of trade and of manufacture. As a commercial city increases in population, some local industries usually spring up. And, similarly, the growth of a manufacturing city usually develops some commercial activity. But, in the main, the city exists because it is either a commercial or an industrial center, the one activity being only secondary or tributary to the other. In many cases it is easy to characterize the world's leading cities as belonging to one or the other of these classes. For example, Pittsburgh, Pa., Birmingham, England, and Lyon, France, will be classed at once as primarily industrial cities. New York, Liverpool, Hamburg, and Hong Kong will be classed as predominantly commercial cities.

The purest examples of commercial cities are to be found in places that are merely points of transfer, bulk-breaking points where the mode of transportation changes. At such points the conditions of life are sometimes so difficult that only the most compelling operations are performed, as in the hot, humid, and unhealthy towns of Matadi near the mouth of the Congo and La Guairá on the Venezuelan coast, in bleak St. Michael near the mouth of the Yukon and Punta Arenas (Magallanes) on the Straits of Magellan, and in dry and dusty Antofagasta and Iquique on the edge of the Atacama Desert. Furthermore, there are hundreds of places with good living conditions that are merely points of transfer, such

as Fort William–Port Arthur at the head and Prescott at the foot of Great Lakes navigation which are engaged in the storage and transshipment of grain.

In some cities the difference between commercial and manufacturing influence becomes difficult or even impossible of accurate discernment. In many cases the commercial city becomes industrial. With superior assembling and distributing facilities and with access to raw materials, the trade center often finds it profitable to engage in manufacture. Thus, New York is not only the world's premier port but America's leading manufacturing city. Commerce was the scaffold that started the city and held it up, while a superstructure of manufacturing, finance, and local business was built upon the framework of commerce. Again, political factors sometimes enter into the equation of urban development. The sites of Washington and Canberra, the capitals of the United States and Australia, were arbitrarily determined by law. Neither city has manufacturing worthy of mention, while their commerce is a by-product of the fact that they happen to be the centers of government and the residence of many thousands of federal employees.

The place of transportation in making commercial cities. Some advantage in transportation is the most fundamental and most important of the causes determining the location of a collecting and distributing center.[1] It may almost be said to be the only cause for the formation of such centers. For some reason or reasons, a certain place is more conveniently and cheaply reached by many people than any surrounding point; and, as a result, they naturally exchange commodities there. The country store is located at the crossing of roads. There also is the village. In a mountain country the market town is at the junction of two or, still better, of three valleys. Another favorite location is the end of a mountain pass or a gap that is a thoroughfare between two valleys. If rivers are difficult to cross, settlements will spring up at the safest fords or ferries. In a level plain, a town will be near its center, and a focus of roads or railroads in such a plain, fertile and populous, will almost surely make a city. Anyone who is familiar with the geography of a peopled area of varied topography can see examples illustrating any or all of these forces.

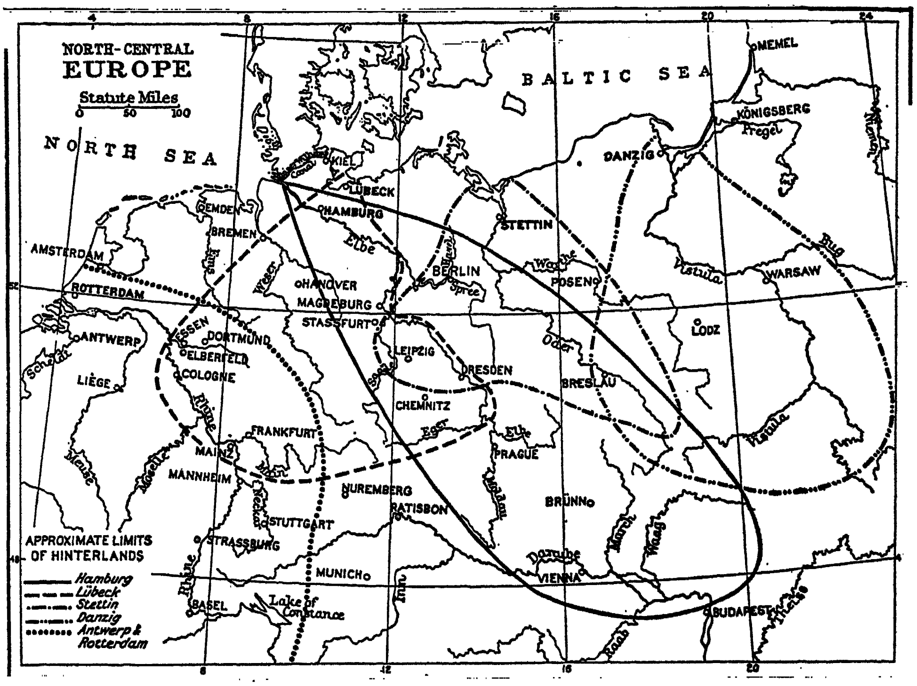
Prior to the coming of the railroad, inland commerce followed the rivers and the lakes. River ports were rivals of seaports, for the navigable river gave its valley cheap access to the sea. Towns and cities developed at or near the mouths of rivers; at or near the junction of navigable streams; on the outer side of conspicuous river bends, where the channel was deeper and a larger trade territory was to be served; at points where transshipment of goods was necessary between deep-draft and shallow-draft steamers; and at the absolute head of navigation. With the coming of the railroad, towns and cities developed beyond the realm of the waterways at points where urban development was previously impossible.

On the other hand, the commerce of many a trade center declined as a result of shifting conditions of transportation and trade. Thus, in George Washington's time ships were small, and Alexandria, Va., on the Potomac had a prosperous trade. But today Alexandria is merely a residential annex to our capital city, while the trade of Virginia and Maryland flows through the seaports of Norfolk and Baltimore. The railroad train has rushed past the river port to the seaport, and the big ocean steamer has taken the trade.

2. SEAPORTS AND THEIR HINTERLANDS

What makes a port? A seaport is a gateway between two transportation realms. On the one hand is the sea, with its trackless but inviting waste offering the cheapest routes for

[1] While it is not always possible to determine the exact reasons for the original location of a particular trade center, in most cases it is possible to determine the factors that have contributed to a trade center's survival and growth. See Eugene Van Cleef, *Trade Centers and Trade Routes*, D. Appleton-Century Co., Inc., New York, 1937, pp. 7–15.



This map shows how some European hinterlands were bounded before World War II. It shows how Rotterdam and Antwerp are dependent for a large part of their commercial prosperity on what goes on in the Rhine Valley, including, of course, the Ruhr. ***George Philip & Son, Ltd.***

commerce with all the world. On the other hand is the land, with its railroads, inland waterways, and highways carrying the commodities of trade to and from the port very much as the blood is carried to and from the heart in our vascular systems. All seaports, therefore, are the focusing points of the commerce of land and sea, bulk-breaking points where the mode of transportation changes.

Like all trade centers, the seaport is a collecting and distributing center. Here cargoes are assembled for outgoing ships, just as the country elevator collects the wheat of many producers for shipment by rail. Here the incoming vessel discharges its freight, which is taken forward to its destination by smaller and more expensive carrying agents—the coasting vessel, the river boat, the railroad, the motor truck, to some extent the wagon, and, in some countries, even the pack train and the human carrier of packs. The great seaport exists because it is a place for the breaking of cargo of ocean ships, just as the country store exists because the boxes and cartons of miscellaneous supplies must there be divided up into numerous small packages for the individual consumer.

Why do some ports flourish while others languish? Many factors determine the prosperity of a port, but four are of outstanding importance: (1) the size and productivity of the hinterland, or the area that is commercially tributary to the port, (2) the ease of access to the hinterland, (3) the suitability of the harbor site, and (4) the efficiency of terminal facilities. While efficient terminal facilities and a good harbor are great assets to the development of a port, no amount of mere harbor convenience will originate or foster the growth of a port if traffic is lacking. Man can build a harbor; he can set up the facilities for handling cargo; he sometimes overcomes great difficulties so that the port may serve a larger area—but only Nature can create the hinterland.

The hinterland. The volume and kind of commerce transacted in a seaport is fundamentally dependent upon the size and produc-

tivity of the hinterland.[2] For example, Bergen, Norway, has little commerce except fish from the sea, because it is hemmed in by mountains and its restricted hinterland has little production except forestry. In contrast, Houston, Tex., serves a large, level, and productive hinterland that gives rise to a large export of petroleum, cotton, and wheat. Not only do hinterlands vary in size, but the hinterlands of competing ports usually overlap (see Fig. 564). Thus, the interior plains of North America are tributary to many ports scattered from the St. Lawrence River to the Gulf of Mexico and the Pacific Coast. While New York surpasses all of these ports in total volume and value of trade, particularly manufactures, Montreal is the leading grain port, Norfolk and Baltimore handle most of the coal export trade, Houston and New Orleans lead in cotton shipments, and so on.

Finally, it should be emphasized that the area served by a port is subject to change, its boundaries advancing or receding in response to changes in tariff duties and inland transportation facilities and rates, the availability of steamship services, the adequacy of terminal facilities, the initiative of exporters and importers, and other variable factors.

The productivity of the hinterland is determined by its natural and human resources, and productivity is more important than size. For example, Tripoli and Calcutta both serve large hinterlands, but the former lies on the edge of the Sahara Desert, while the latter is the gateway of the fertile and populous Ganges valley. Rotterdam and Antwerp serve smaller areas than New Orleans, but their commerce is far greater, whether it be measured in terms of value, weight, or the number and capacity of ships that enter and leave during the course of a year. Furthermore, some hinterlands offer a variety of products for export, while others yield only a single commodity. Thus, Buenos Aires ships large quantities of wheat, corn, flax, meat, wool, quebracho, and other products, while Iquique exports only nitrate. Fortunate is the port that lies in the midst of a populous and productive area providing both a great market for imports and a large and varied supply of exports.

Access to the hinterland. Unless the resources of a hinterland are accessible, they remain potential rather than actual bases of trade. Cheap and easy access to the hinterland is largely a matter of location and transportation. An inland location on a deep arm of the sea is good, for ocean vessels can travel farther inland, giving the exporter and importer the maximum advantage of low ocean freight rates. Montreal lies 1002 miles from the sea on the deep St. Lawrence River, and its interior location makes Montreal a far better port for Canadian trade than Halifax on the Nova Scotian Peninsula.

Besides easy access from the sea, the great seaport—the international trade center—must have easy access to the land and to the centers of population that it serves. This access is best supplied by a river valley with water transportation on the river itself and canals and railroads that can be built most easily along watercourses. Nearly all important seaports are at, or near, the mouths of rivers. Philadelphia, Boston, and Baltimore were the rivals of New York until the opening of the Erie Canal. The low-level route of the Erie Canal through the Hudson-Mohawk depression was the most favorable of all trans-Appalachian routes for the construction of railroads and highways, with the result that New York continued to have easier and cheaper access to the heart of the continent than any of our Atlantic ports.

As in North America, so in other continents, the navigable river has dominated the growth of seaports. It is not by accident that London and Liverpool are upon the Thames and the Mersey, respectively, with their canal

[2] One of the geographer's most difficult problems is to determine the boundaries of the area that is commercially tributary to a port. See Arthur J. Sargent, *Seaports and Hinterlands,* Adam and Charles Black, London, 1938.

and railway connections with the interior. Hamburg has outstripped Bremen because the Elbe is navigable even beyond the Czechoslovakian boundary, while the Weser gives Bremen only inferior communication with the interior. The Nile has made Alexandria; the Ganges, Calcutta; the Yangtze, Shanghai; and Canton and Hong Kong, the outlets for the trade of southern China, lie near the mouths of the Si, Tung, and Pei rivers.

The harbor. Some ports have splendid natural harbors; others have artificial harbors built at great expense; while some ports have no harbors at all, vessels being loaded and unloaded with the aid of barges and lighters in an open roadstead. No harbor is perfect in every respect, but the more it approaches the ideal, the better it serves the needs of shipping and trade. The advantages of an ideal harbor, with brief comments, may be enumerated as follows:

1. Protection from winds and waves. Without such protection, a ship must weigh anchor in times of storm and seek the comparative safety of the open sea. Many a port has built a breakwater of concrete or stone to obtain such protection; for example, Madras, the chief port on the harborless east coast of peninsular India. A few inland cities have dug out a basin and connected it with the sea by canal; for example, Houston, Tex., and Manchester, England.

2. Deep water in the channel and close to shore, not exceeding 100 feet in depth. New York has 40 to 45 feet of water in its main channels, which are kept clean by tidal scour and some dredging and which accommodate the largest ocean liners. Rotterdam, Antwerp, Shanghai, and most river ports must spend money on constant dredging. London, Hamburg, and Bremen had to build subports nearer the sea to handle the big ships of today. This requires much lightering.

3. Abundant anchorage space. Superliners such as the *Queen Elizabeth* require a radius of half a mile to turn around. Few harbors are as commodious as New York, Hampton Roads, Va., and Rio de Janeiro, each of which could hold the ocean-going merchant vessels of the entire world.

4. A harbor entrance that is wide, straight, and deep. Many ports lack this advantage, and congestion, delay, and high pilotage charges are often the result.

5. A tidal range of less than 15 feet, so that ships may load and unload at all stages of the tide. At New York the tidal range is 4½ feet; at Baltimore, only 1 foot; at Liverpool and Le Havre, 25 to 30 feet. Many ports of western Europe had to build tidal basins equipped with locks, ships entering and leaving only at high tide.

6. Freedom from ice. Sometimes powerful ice-breakers can be used to maintain an open channel. Such ports as Montreal, Archangel, various Baltic ports, and Vladivostok lose trade when navigation is closed by ice.

7. Freedom from fog. New York has 1064 hours of fog per year, or an average of 2.91 hours per day. In spite of the use of bells, whistles, radio, and radar, shipping sometimes comes to a dead halt, resulting in a costly loss of time.

8. Ample room for wharves, transit sheds, warehouses, belt-line railroads, and other terminal facilities. Such fiord harbors as Bergen, Norway, where precipitous slopes adjoin the waterfront, have almost no room at all. Seattle had to excavate a hill to provide room for buildings. On New York's crowded Manhattan Island waterfront space is limited and expensive (see Fig. 562).

Terminal facilities. Human labor is commonly used for loading and unloading cargoes in many Oriental ports, where labor is cheaper than machinery, but modern ports have elaborate and expensive terminal equipment. Vast sums of money have been invested in wharves; cranes, derricks, conveyor belts, and other mechanical facilities for handling freight; transit sheds and warehouses for the protection and storage of freight; and belt-line railroads, barges, lighters, and motor trucks for the local assembly and distribution of cargoes. The port of New York has about 1800 piers and quays along its 650 miles of improved

waterfront. In contrast, the ports of London, Liverpool, Hamburg, Bremen, Amsterdam, Rotterdam, and Antwerp all together do not occupy half as much space as the port of New York. Nature made New York harbor. Men made these European harbors. Each of these European ports has a harbor that is little more than a hole dug out of the mud, yet at times each has handled nearly as much traffic as New York. It is all-around port efficiency rather than the length of the waterfront that counts.

The waterfront is a busy place with many functions to perform, and Europeans have long recognized that it is vested with a public interest. In Europe most ports are either owned and operated by the government or by a board of impartial, nonsalaried representatives of the municipality and the commercial interests of the port. In the United States most of the best waterfront space long ago was taken over by the railroads and other big corporations for private use and private gain.[3] As a consequence, local industries have often been forced to use inferior locations along the waterfront, and in some cases steamship lines have been excluded from a port because wharfage space and other facilities were under the control of rival companies. Indeed, the crowded waterfront is the weakest link in the American transportation system today.

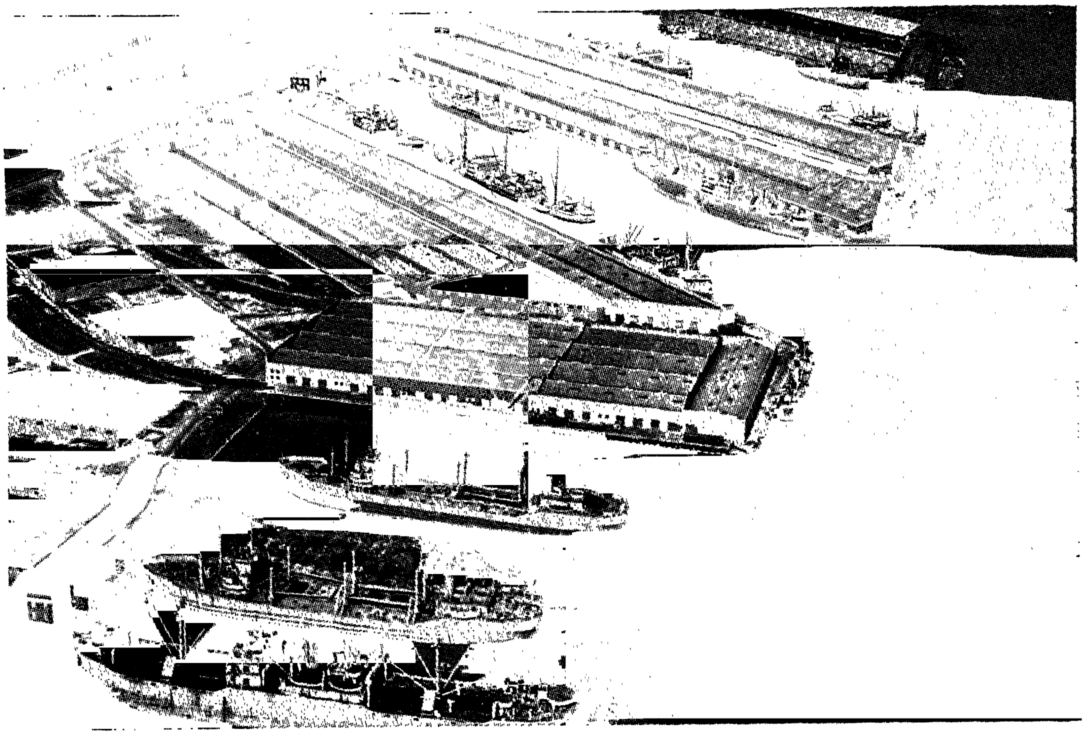
Types of ports. One of the changes in the world commerce of the past has been the pronounced separation of ports into classes. On the basis of traffic, ports may be divided into two groups: passenger ports and freight ports; while the latter may be subdivided into two major classes: raw-material ports and manufactured-goods or general-cargo ports.

Only a few ports have predominantly passenger traffic. Such ports are Southampton and Plymouth in southern England, where passengers, mail, and express are unloaded from great transatlantic liners and rushed to London on special nonstop trains. Likewise in France, passengers disembark at Cherbourg (and to a lesser extent at Le Havre) and hasten by fast trains to Paris. In Argentina combination passenger and cargo liners often call first at the port of La Plata, passengers taking the train to Buenos Aires while the ship proceeds slowly through crowded waters to its wharf in Buenos Aires about 40 miles upstream. Because of location, such ports are able to facilitate the inbound and outbound movement of passengers, mail, and express, such traffic requiring rapid transportation.

Raw-material ports today are far more numerous than manufactured-goods ports. The filling of the channels of trade with the many bulky, cheap, or perishable articles has produced new trade conditions with less dependence upon great ports and distribution centers. In order to avoid the expense of long rail hauls, cheap and bulky commodities generally seek the nearest port of exit, and they are shipped to best advantage in full cargo lots. Since the vessel takes no other freight, it can load at any small port near the place of production. It is easy and profitable for a vessel to go to a small Texas port for wheat or oil, to Tampa for phosphate, to Iquique or Antofagasta for nitrate, to Gray's Harbor or Vancouver for lumber, to Lulea or Bilbao for iron ore, to Zamboanga for copra, to Vizagapatam for manganese, or to Cardiff, Newcastle, and Norfolk for coal. Many of the world's great raw-material ports are small places indeed.

In contrast with the small raw-material port, the manufactured-goods or general-cargo port handles a tremendous variety of manufactures and semimanufactures. Such is the case of New York, London, Hamburg, Rotterdam, Kobe, and Yokohama. Only a large port serving a densely populated area can export and import great quantities of manufactures. Such goods move in small shipments of all shapes and sizes, and many are needed to fill a single

[3] New Orleans, Mobile, and San Francisco are public ports; Seattle, Portland, and Gray's Harbor are partially administered by port authorities similar to the public trust ports of London and Liverpool; New York and a few other ports are semipublic ports; but most American ports are under private ownership and management. See Abraham Berglund, *Ocean Transportation*, Longmans, Green & Co., New York, 1931, pp. 133–134, 145–149. State-owned docks at Mobile are shown in Fig. 568.



A raw-material port—Mobile, Ala. City does not crowd the docks as New York, San Francisco, and London do. ***Mobile Chamber of Commerce***

ship. These high-valued goods of low bulk and weight can pay for travel long distances by rail to seaboard. Because of their value, they almost inevitably seek a big port with fast, numerous, and direct steamship connections with the rest of the world. Manufactured-goods ports, therefore, require the fast and regular services of ocean liners, while raw-material ports often depend upon the slower but cheaper transportation provided by tramp ships.

Most of the world's ports are either importing or exporting ports, and it is unusual for a port to have an equal share of imports and exports. Over one half of the imports of the United States in terms of value, or more than one third in terms of weight, enter the country through the long-established ports of New York, Boston, Philadelphia, and Baltimore. These four ports lie adjacent to the greatest centers of population and manufacture, and are the cities with the oldest and best ocean connections. Likewise, San Francisco, the old gateway for Oriental imports, is our leading port of entry on the Pacific Coast. In contrast, the new ports of Texas are distinctly raw-material ports, with a heavy excess of outbound traffic (see Table 32:1).

New York: the world's premier port. Of all the world's cities, New York is the most gigantic product of transportation. Nowhere else in the world is there such a supreme focus of routes by land and sea. None of the world's seaports equals New York in the total value of its foreign commerce. Each year the total net tonnage of vessels entering and clearing the port of New York is more than double that of London, its nearest rival. In terms of cargo tonnage, it ranks second among American seaports in exports and first in volume of imports and receipts of coastwise cargo, but its outbound movement of coastwise cargo is surpassed by that of several of our raw-material ports (see Table 32:1).

New York is North America's greatest gateway for the inflow and outflow of manufactures that loom high in value, but that is not all. Inbound vessels bring large quantities of petroleum, coal, coffee, raw sugar, crude rubber, wood pulp, tin pigs and bars, cacao,

bananas, vegetable oils, jute, cotton, wool, and lumber, while outbound vessels carry scrap iron and steel, wheat, leaf tobacco, apples, and many other commodities.

It was not by accident that New York has become the world's greatest seaport and an international trade center of the first magnitude. The city is centrally located in a densely populated, wealthy, industrial and commercial area along our northeastern seaboard. It faces Europe, our greatest market for exports and a leading source of imports. Its immediate hinterland is both a great producer and consumer of goods. Farther inland lies the continental interior, a tributary hinterland that is unrivaled in size, productivity, and purchasing power. To this peerless hinterland, New York has long had cheap and easy access. To the outside world, it has more regular steamship services than any port in the Western Hemisphere.

At New York's doorstep the drowned valley of the Hudson provides one of the world's best harbors. Its terminal facilities include some of the most modern equipment in use today. Its exporters and importers are more aggressive than ever before, and capital is easily available for the financing of foreign trade. New York today is the world's greatest financial center and a great market place where business transactions occur daily that affect the lives of men throughout the world.

TABLE 32:1. Cargo Tonnage of Principal United States Seaports, 1952[a]
(thousands of short tons)

Port	Total	Imports	Exports	Coastwise Receipts	Coastwise Shipments
New York Harbor	87,378	27,799	8,099	41,778	9,702
Hampton Roads[b]	42,399	3,012	23,206	5,345	10,836
Baltimore	30,040	14,843	6,573	7,187	1,437
Houston	29,980	1,922	6,039	738	21,281
San Francisco Bay	29,586	2,248	3,429	13,055	10,854
Philadelphia	25,447	12,275	3,068	8,053	2,051
Boston	17,925	4,850	336	11,595	1,144
Port Arthur, Tex.	17,483	3	1,678	1,550	14,252
Beaumont, Tex.	17,213	42	434	1,859	14,878
New Orleans	17,028	4,241	6,417	666	5,704
Los Angeles	16,743	1,306	1,830	5,257	8,350
Portland, Me.	11,264	7,827	168	2,907	362
Texas City, Tex.	9,625	3	1,366	495	7,761
Portland, Ore.	8,495	118	1,530	6,304	543
Seattle	7,464	285	893	5,610	676

a All data exclude purely local harbor traffic and commerce with ports on internal rivers or canals.
b Norfolk and Newport News, Va.
Source: The Board of Engineers for Rivers and Harbors, U. S. Corps of Engineers, *Water-borne Commerce of the United States, Calendar Year 1952,* Washington, December 1953, pp. 14–16.

3. THE ENTREPÔT CENTER

The nature of entrepôt trade. In addition to ordinary incoming and outgoing trade,[4] some ports are engaged in the distribution of foreign goods to foreign countries. Such re-export or intermediary trade is known as entrepôt trade. Thus, London has long had a large commerce in goods that do not originate in Great Britain and are not intended for distribution and use in Great Britain. Likewise, the island of Hong Kong is an entrepôt center for the trade of southern China, this center having been established by the British in 1842 at a time when Chinese ports were closed to foreigners. Prior to World War I the island

[4] The ordinary traffic of a seaport may be divided into two classes: (1) local traffic, consisting of outbound cargo that originates within the port and inbound cargo that is destined for the port, and (2) through traffic, or cargo that originates within or is destined for the hinterland.

of Zanzibar was an important entrepôt center for the east coast of Africa, vessels calling at the island to leave goods for later distribution along the coast and to pick up cargoes that had been previously assembled by small coastal ships. The entrepôt center, therefore, is interposed between a producing and a consuming country, just as in domestic trade a middleman stands between producer and user.

The commodities that are best adapted to the entrepôt method of distribution are nonperishable goods that are of high value in proportion to their bulk and weight. By having high value the freight rate is relatively insignificant, and the long and devious journeys are not a serious handicap. Having small bulk, there is not the demand for a whole shipload of them in any one place, and so it is really cheaper to let them wend their way by transshipments through the common distributing center or entrepôt. A second factor of influence is the question of distance. The more remote the origin and destinations of the traffic, the stronger is the hold upon this trade of the entrepôt with its organization of routes, ready to serve and hard to duplicate.

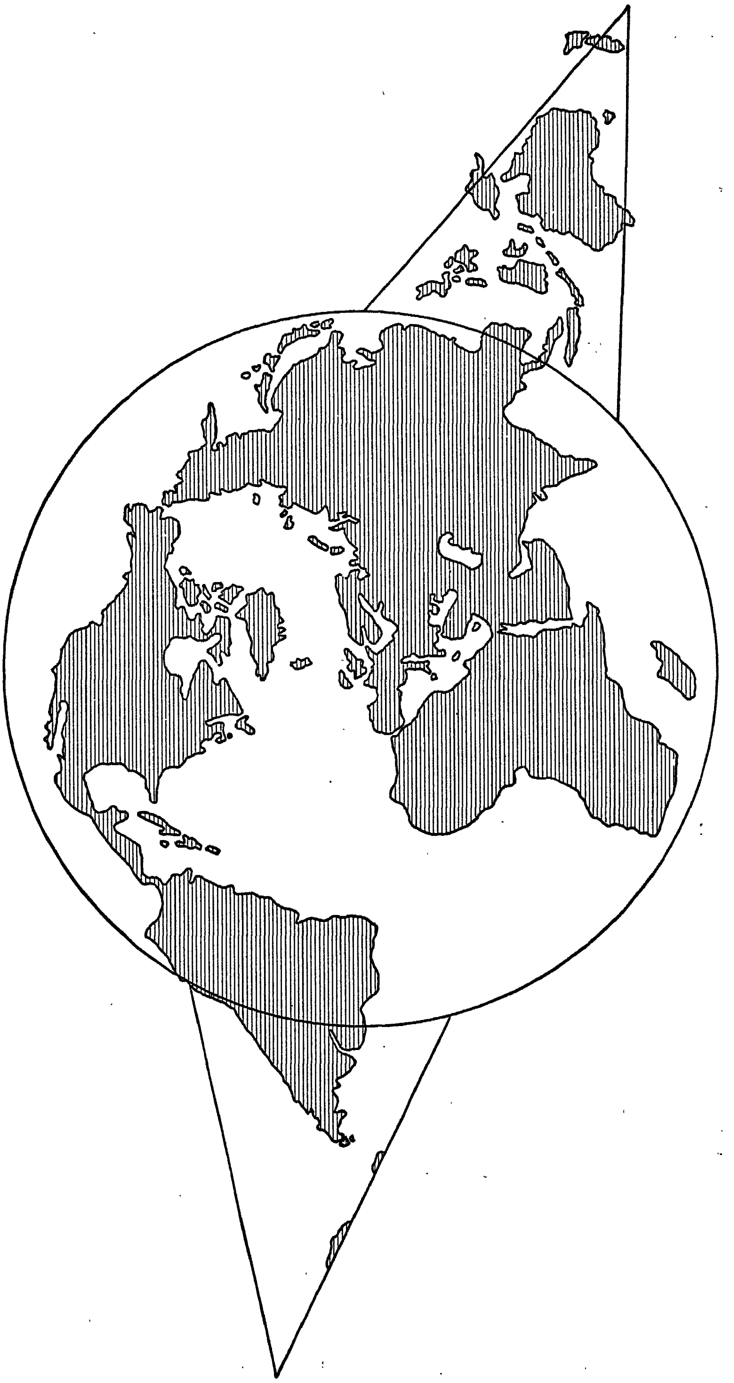
Entrepôt trade of the past. For centuries prior to the Industrial Revolution, world commerce was predominantly a trade in luxuries and exotics. In this trade the entrepôt center played a major role. An outstanding and very profitable branch of commerce consisted of the exchange of goods between the Orient and Europe. From the Orient came spices, silk, tea, drugs, perfumes, embroideries, velvets, satins, fine cotton goods, curios, and precious stones—goods of small bulk and very high value. In return Europe was able to ship some raw wool, hides, woolen goods, and common linen, but she had to pay for most of her Oriental imports with gold and silver. These commodities were shipped in small lots and could be easily handled by camel caravans on the long overland routes to the sea or across Asia and by the small sailing vessels of those days. Oriental products were consumed throughout western Europe, but always in small quantities. They were produced in a remote part of the world, and it was commercial economy that they should be distributed among Western countries from some Western entrepôt.

The city best fitted to render this distributing service was the one to which varied industry had given the most widespread vessel connections. The shifting of this trade from route to route and from center to center is an interesting study of commerce as affected by war, politics, discovery, invention, geographical control, and the economic conditions that resulted from these forces. During the ordered period of the Roman Empire this commerce was divided among many cities. After the fall of the Empire in the West, Constantinople, the seat of the strongest European power, became the richest commercial city of Europe and one of the important gateways to the East. Following the decline of the Byzantine Empire, one city or another controlled a large share or even had a monopoly of the valuable commerce that passed between eastern Asia and western Europe, and each became an object of envy for the trading world.

For years Venice monopolized the trade with the Orient, but after Vasco da Gama's discovery of a sea route to India via the Cape of Good Hope, commercial supremacy passed to Lisbon and in turn to Bruges, Antwerp, Amsterdam, and London. Amsterdam's monopoly was less complete than that of her predecessors, and the predominance of London was never so complete as that of Amsterdam.

London: the world's greatest entrepôt center. From the middle of the eighteenth century until the present day London has remained the greatest of all entrepôt centers. London's supremacy was the heritage of Britain's quest for empire. As a result of long but victorious wars with Spain, Holland, and France, Great Britain emerged as the world's greatest commercial nation served by the most powerful navy and the largest merchant marine, and London became the world's greatest financial and trading center. With the growth of the British Empire, increasing quantities of colonial products came to London for local consumption and for redistribution to Europe. With the coming of the Industrial Revolution and with the development of many new coun-

Map of the world, taken from a globe with London as the pole. Areas as from the globe, except for a little exaggeration from "pole" to Equator. Shows London is the center of the land mass. It illustrates Mr. Stefansson's claim that the Arctic is not a real ocean but a cold Mediterranean Sea.



tries overseas, both the direct and re-export trade increased tremendously. With the development of steamships and railroads, the luxuries and exotics of former years declined in price and no longer dominated the entrepôt trade. Wool, hides and skins, teas, copper ingots and bars, and crude rubber now rank high among Britain's re-exports. In 1952 British re-exports were worth £143,811,000, as compared with £61,525,000 in 1938.

The entrepôt trade of Great Britain has been marked by a number of long-run changes.

At all times the entrepôt trade has been subsidiary to trade that was essentially local in its origin or destination, but the relative importance of entrepôt trade has been steadily declining. In 1952 goods destined for re-export accounted for only 4% of total imports, as compared with about 20% from 1870 to 1900. Secondly, the entrepôt trade has come to include a much greater variety of products. Of the articles that dominated the trade in 1800, only tea remains of outstanding importance, and it is no longer a luxury. Thirdly, London and Liverpool are faced with increasing competition from Rotterdam, Amsterdam, and Copenhagen in the distribution of overseas products destined for the countries of western Europe, while New York now imports directly from producing countries many commodities that once were shipped through Great Britain, such as tea, silk, rubber, jute, Egyptian cotton, wool, coffee, and cacao. Hence, the relative importance of London among the world's entrepôt centers has declined.

That London still ranks first shows the advantage of her location, her shipping connections, the reluctance of traders to change their habits, and the tremendous power of the worldwide contacts of British importing brokers, banks, and shipping companies. In spite of the fact that other entrepôt centers are developing, it is unlikely that London will be displaced by any single successor.

Decline of the world entrepôt center. While it is probably true that the total value of entrepôt trade throughout the world is greater than ever before, the relative importance of re-export trade is steadily declining. The pre-eminence of the world entrepôt center is on the wane largely because of two developments: (1) the tremendous increase in the bulk of world commerce and (2) the multiplication of steamship and railway lines which enables many cities to serve as entrepôts for limited areas.

On the question of the supremacy of commercial cities, the future cannot be judged by the past. The mechanical improvements of modern times have made a new industrial and a new commercial world that must be judged by the new conditions.

The great inventions of the present have increased manyfold the materials of commerce. These changes have permitted a rapid increase in population in commercial countries and have brought about the settlement of new continents. Wildernesses in North and South America, Australia, and Africa have become the homes of people having wide commercial relations. Where an occasional trading ship loaded with valuables and trinkets made a bartering cruise in 1800, fleets of steamers assembled in 1900 to carry away the coarse bulky staples of international trade; and, in the first decade of the twentieth century, the progress in this direction was more rapid than ever. No city could handle it all if she tried.

The increase of direct connections and the growing complexity of the international trade-route net are pronounced and characteristic tendencies of the later decades of the nineteenth century and of the present. Hence, there is a tendency for each country to raise up its own entrepôt. We can indeed see the progress before our own eyes, for the centrifugal or decentralizing forces continue.

Other cities become entrepôts. London is still the leader, but other British ports now have direct lines to the East. In 1939 German lines went from Hamburg and Bremen; French lines, from Le Havre and Marseilles. There are frequent and regular eastern sailings from Antwerp and Genoa, and at less frequent intervals from Copenhagen. New York also has regular connections with the Orient, Australia, Africa, the coasts of South America, and the ports of the Mediterranean and the Baltic. Before World War I, Hamburg had in large degree succeeded London and Liverpool as the basis of foreign-goods supply for Scandinavia and the Baltic; but almost before Hamburg appeared secure in her new trade position, lines of steamers were beginning to carry the products of America and the Orient direct to Stockholm, to Copenhagen, and to the Russian ports.

Lines from the United States to Genoa have

largely displaced trade via Liverpool, and lines from New York to Istanbul (Constantinople) and the Levant have reduced the trade to the United States via Genoa and Marseilles. An examination of port connections the world over will show the same decentralization of trade and decline of entrepôt centers.

Before World War II the increasing trade of the ports of North China adjacent to the Gulf of Pohai (Pechili) made it profitable for occasional vessels to take cargo direct from Europe and America to ports of Tientsin, Yingkow (Newchwang), and Talienwan. At one time nearly all the trade of East Asia was first laid down at the great entrepôts of Hong Kong, Shanghai, and Yokohama for final distribution in small craft. If commercial development on this north coast resumes and satisfactory harbors are made, there will be less and less dependence upon Shanghai, Yokohama, and Hong Kong and more direct connection with the remote bases of supply at San Francisco, Seattle, New York, London, Liverpool, Hamburg, and Marseilles.

Effect of grading goods. The question of international distributing centers is not alone affected by routes of transportation and the establishment of direct connections. There are many other factors. One of them is the gradability of goods. In general, it may be said that commodities having such uniformity as to be accurately graded and sold by grade can be, and usually are, sent directly to their destination with little regard to entrepôt, while commodities that cannot be accurately described but must be inspected before purchased are often bought and sold at some convenient intermediate point, which has come to be recognized as a "market" for a certain commodity or commodities.

Wheat is an example of the gradable commodities. A buyer is reasonably certain what he will get when he buys No. 1 or No. 2 of a certain kind of wheat, graded in a certain market. Accordingly, ships load in Oregon, Argentina, or the Atlantic Coast of the United States or Canada and start toward Europe. The cargo is sold en route by a cablegram, and the captain of the ship learns his destination by radio.

The entrepôt problem is universal. It should be kept in mind that decentralization of trade does not destroy the old entrepôt center. The impetus of an early start, the importance of an established reputation, the availability of capital, and the world-wide contacts of individual business firms are forces that enable the old entrepôt to continue handling large quantities of goods that might be handled at equal or even better advantage and with less labor elsewhere. We have seen that the relative importance of London has declined because of competition, but the volume of her entrepôt trade is still great. The same can be said of New York, Rotterdam, and other entrepôt centers.

While both old and new entrepôt centers continue to grow, it is clear that the day of the world entrepôt has passed, and its place is being taken by an ever-increasing number. As a result we now have a score of centers that are as large as was Amsterdam in her distributing prime, each handling as much trade as she did in that day. But the fact remains that of the many, many thousands of towns and cities upon the face of the globe, all but this favored score connect with the great arteries of commerce through some entrepôt of greater or lesser importance. Therefore, it is plain that the problem of the entrepôt is universal, and their number merely serves to heighten interest in them. We live in a competitive world.

4. THE BARGAIN CENTER

The buying and selling of distant commodities. A city may be a commercial center in two ways—first, as an actual distributor of goods; second, as a transaction center, a place where bargains are made for goods that are elsewhere and which may never be brought to the center. The transactions in *C* often relate to goods in *A* to be sent directly to *B*. The transaction center is the lineal descendent of the eighteenth-century distributing center. In the days when the communica-

Lloyds—the heart or brain or nerve center of the shipping world. In its center, hanging below the clock, is the Lutine bell. It tolls whenever a ship is reported lost. These men, like those in Figure 11, may be agents, acting for a principal they never saw, trading in property neither ever saw—one of the bases of the developed world.

tion of ideas and the carriage of goods depended upon the slow and uncertain sailing vessel or on the equally slow and uncertain means of land conveyance, it was usually necessary to have the goods on the spot before they could be the subject of bargain or sale.

The steamship, the railway train, and the telephone, telegraph, cable, and radio, however, have made a commercial world remarkably new in its methods of management as well as in its staple commodities. Electric communication gives instant and constant information concerning stocks on hand, the crop prospects, and other conditions that affect the prospective supply. Standardization either by manufacture or by grading makes it possible for buyer and seller to bargain definitely for commodities neither has seen or ever will see. The steamship gives quick delivery; and, what is of equal importance, it far exceeds the sailing vessel in the certainty of reaching port in a stated time. Commercial transactions of today may thus concern commodities in distant places and for future dates. And, although the movement of goods may be decentralized, it still remains advantageous in a surprising number of cases for the men making the bargains to assemble in groups at some convenient center.

Advantages of centralized bargaining. The sales and purchases are made in the center, because it is easier to carry on such operations where many buyers congregate, where many compete in the same business, and where representatives of many businesses can serve each other. This attracting force is somewhat akin to that of an auction, and it draws those engaged in the bargaining or transaction side of commerce into groups that are often quite irrespective of the location of the commodities in which they deal. This centralizing force operates in local, interstate, and international trade. It is usually strong enough to collect into a small district of a city all the firms engaged in the same line of business, provided the business is not of the retail nature requiring scattered location close to its patrons. The steamship agents and brokers of London, Liverpool, New York, and San Francisco are all collected into small districts of their respective cities through which one can walk in a few minutes. The London wool brokers have their still more restricted locality, and two or three small streets are the headquarters for the general produce brokers. An hour's walk through the wholesale districts of New York, Philadelphia, London, Hamburg, or any of many smaller cities will suffice to give the observer many examples of this grouping of mercantile firms engaged in the same business.

The exchange, of which the stock exchange is a conspicuous example, represents the highest form of this grouping or centralization. There the principal buyers and sellers of a particular commodity actually congregate in a single room to facilitate their work. The exchange method of doing business may be applied to most commodities of which the price may be quoted. London has a stock exchange, a wool exchange, a metal exchange, Lloyd's (the underwriters' exchange), the corn exchange (grain), the coal exchange, the royal exchange (bankers, manufacturers, etc.), and the Baltic, the world's chief center for the chartering of tramp ships and an important center for the purchase and sale of full cargoes of grain, timber, oil seeds, coal, and other commodities. New Orleans, Houston, Liverpool, and Bremen have cotton exchanges; New York has cacao, rubber, and other commodity exchanges; and Leipzig had a book exchange. Hamburg has one very large exchange, attended by most of the brokers and wholesale merchants of the city, where a variety of transactions takes place; but the grouping principle works within this general bourse or exchange, for there is a steamship corner, a grain corner, a coffee corner, a stocks' corner, etc.

By similar centralization the manufactured products of an industrial district are usually sold at some central point to which in many instances they are never sent, being shipped instead directly from the factory to the point of final destination. Manchester is the selling center for cottons produced in a score of smaller cities and towns in Lancashire. Offices in the business section of Philadelphia sell a large part of the manufactures produced in the mills of the suburbs and nearby towns. The same is true in Boston and many other large cities. Most of the shoes made in eastern Massachusetts are sold in 100 or more offices located in a restricted area in Boston.

National centers for management of foreign trade. In the same way, the transactions of foreign trade are centralized in the commercial metropolis. Decentralization of commodity traffic has been an accompaniment of the growth of the new commerce; but electric communication and the fast mail have helped to keep up the transaction center by putting the selling agent in easy touch with the factories and local centers of the producing and consuming districts in all parts of the world.

Sales for the foreign trade or to the distant consumer cannot be arranged easily from cement works located in the Allegheny Mountains of Pennsylvania or Virginia, from the Georgia cotton mills, or from the phosphate mines of Tennessee or Florida. Consequently, the selling agencies are in New York, although the cotton cloth may go to China by way of Vancouver Sound, the phosphate be shipped from a Gulf port to Japan, and Virginia cement reach the sea at Norfolk and Newport News or go by rail to interior points. The products of the scattered industries of Great Britain are largely sold in London, but tens of millions of pounds sterling worth of the goods thus sold go direct from the point of production to Liverpool, Manchester, Hull, Glasgow, Bristol, and other ports for export.

There is a general tendency toward the establishment of direct connections between consumer and producer, especially when the currents of trade have become regular and confidence is established; but the markets for new industries or the new lines of trade in many of the old industries are found through the agencies of the selling center. Here also the new purchaser usually finds it is easier to purchase his stocks, and at all times the individual trader dealing directly has the opportunity to better his condition by selling through the transaction center and getting the advantage of a competitive market.

International bargain center. The transactions of the wider international trade are also centralized. London, the last great international distributor, is still a large international seller. With the convenience of telegraph, cable, and radio, the London distributing merchant often found that, upon the creation of direct communications between foreign countries, he could continue to make the bargains and arrange other details although

A trading pit, one of several (wheat, corn, oats, etc.) on floor of the Exchange. Traders stand around a pit so they may see each other better. ***Chicago Board of Trade***

the goods no longer passed through London. He knew the conditions of producers of both Eastern and Western markets, and the direct connections that have sprung up merely enabled him to deliver more quickly by shipping his goods direct. Thus, the counting house stayed while the warehouse passed away.

London has come to be a dealer in goods which may never at any time be within 5000 miles of Great Britain. For example, London brokers and London merchants once had a practical monopoly of the international sales of pepper, Manila hemp, Indian jute, and Burma rice. The world's supply of each of these four commodities is produced in a comparatively small region and consumed all over the world. The high value and limited supply of the annual crop would probably lead to disturbing price fluctuations if the central London firms did not act as a sort of regulator. The Londoner is in constant communication with agents in the centers of both production and consumption. He has a world knowledge of this particular trade and is able to conduct business more safely than is the firm in New York or Marseilles, should it attempt to buy hemp, jute, or pepper directly from the dealer in the point of shipment. This broker is the consummate commercial geographer.

The commodities that are subject to the centralized control of London sometimes go by London, Liverpool, or Hamburg for convenience of transshipment to final destination in America or Europe, but they more often go direct. For example, the Burma rice goes in full cargoes from Rangoon to Brazil and the West Indies, while shiploads of crude rubber from Singapore go directly to the United States.

The influence of capital. The international transaction center requires a central location, a line of business that is carried on in widely separated places, and, in addition, an abundance of capital. Usually capital is more plentiful in the center than in the commercial outposts, for the central management of a distant business operation is at times only possible by the use of capital from the controlling center. In this respect the relationship of the distributing center is again shown.

The London firms can hold the fiber trades only by buying the hemp in Manila and the jute in Calcutta. The rice-distributing firms of Europe own the cleaning mills in Rangoon, Bangkok, and Saigon. This central control goes further and sometimes takes a lien on the unharvested crops. The white grapes of southern Spain are usually sold in or through London to offset the account of the merchant-banking firm that has, through its local agent, advanced the money necessary for the expen-

sive oak casks and cork packing. An American importer of these grapes bewailed his inability to buy them direct from Spain, but he could not break the hold of British money unless he had a bank in Spain. He was not a banker; so he got his grapes in London and sent them across on the fast transatlantic liners at little if any sacrifice of time or freights. The long-established use of London capital has given the London capitalist a controlling voice in the sale of many products. For a long time much U. S. cotton was controlled by British firms which advanced money to large cotton factors, who advanced it to small cotton factors, who advanced it to growers, who in turn made advances to sharecroppers. The growing surpluses of American capital since World War I and II have made New York an important center for transactions of this nature.

As the trading countries come to possess more adequate supplies of capital for their own use, and when the trade assumes larger proportions, the international center loses, at least proportionally. When the buyer and the seller manage a transaction without mortgaging the goods in transit to a financier in a third country, there is less need of the services of the broker in the international transaction center. There is accordingly a tendency toward a decentralization of management as well as a decentralization in the actual handling of goods. But the two decentralizations do not accompany each other. In point of time the direct movement of goods precedes the direct management of the business. The latter may be indefinitely delayed. The supplies of capital may remain low, causing a dependence upon foreign bankers. Few countries have or promise to have sufficient capital for their own needs. Since the commercial character of the traders in some countries is not reliable, no one dares trade with them who is not fully acquainted with them—which usually means having an agent on the spot. The trade of some countries will therefore continue to be largely transacted through the centers in the financial countries.

In the United States the industries are conducted upon an unprecedented scale, the mercantile classes are relatively reliable, and the accumulation of capital has been rapid. As a result, direct bargaining arrangements have been established, at least for the staples of American trade. There is no single European center for the trade in U. S. grain, cotton, or lumber. American merchants deal directly with a dozen European cities. Sometimes a London broker succeeds in placing a cargo of American grain or lumber in some other city, but this is unusual, and he must divide his brokerage with the agent in the other port. The grain cargoes from Canadian and Australian ports are usually sold by London brokers, although they may go to any continental or British port. The same is true of East Indian teak, West Indian mahogany, and a large share of the Brazilian coffee that goes to continental Europe.

Direct control of distant industries from the bargain center. There is still another stage in this bargain-center control, the entrepreneur stage. The capitalists, at first European but increasingly American, actually carry on industries and manage them and sell the product through the headquarters in the capitalistic center. Hamburg was the market for the German coffee plantations of Guatemala; Amsterdam was for years the chief market for the Sumatra tobacco grown in the East by the Dutch companies. The jarrah paving-wood industry of Western Australia is all managed in London.

London has had thousands of companies doing business abroad, and, if one walks through the business districts and reads the signs upon the office buildings, he can familiarize himself with geographical names in every continent. New York is following in the steps of her commercial mother, and she is not alone among U. S. cities. A whole floor of a New York skyscraper is occupied by the American office force of a single company operating sugar plantations in Cuba.

It should be emphasized that this capitalistic development has only begun. A mere corner of the world, say ½ million square miles or 1%

of the earth's land surface, has capital to spare. All the vast remainder of the world must depend upon imported capital for the execution of any considerable enterprise, such, for example, as the building of a railroad. This is true of the entire continents of Asia, Africa, and South America, the East and West Indies, Australia, Central America, Mexico, most of Canada, and most of the United States. There has long been much control of industry in our western and southern states by northern capitalists. Throughout the nineteenth century a few countries of northwestern Europe were the sole exporters of capital, but after World War I most European countries became borrowers from the United States, and after World War II even Great Britain turned to us for financial aid. Since World War I no country has invested so much capital abroad as the United States, and New York has displaced London as the world's major financial center.

The rise of international bargain centers in the United States. For years Hamburg, Amsterdam, and Paris have been encroaching on the supremacy of London, and World War I pushed New York to the leading position. One of the ways by which this happened was the sale of British foreign investments during World War I and again in World War II to help the British government. Many lands look to New York for capital funds.

New York's dominance in international transactions is but a natural next step to its previously established dominance in the industries of America. A surprising amount of national and internal business is done by men in New York City. Here men make deals in Montana and Arizona copper, Oklahoma oil, Maine spruce lands, Georgia pine lands, California water-power plants, Virginia rayon plants, Florida phosphates, West Virginia coal, and Pennsylvania cement works. Most of the larger railroads of the country have offices there, and those who supply them must also have offices there. The list might be drawn out indefinitely, for there is not a state in the Union that does not have lands, enterprises, and resources managed from New York, the bargain center of America.

As this country invests more capital in foreign lands, the office signs of New York become more and more of a gazetteer of the world. As never before, our commercial and financial frontiers are global. American firms with headquarters or offices in New York manage banana and sugar plantations of the Caribbean area; mining and oil enterprises in Canada, Latin America, Iraq, and Saudi Arabia; railroads and power plants in many Latin American countries; and branch factories on every continent. Chicago meat-packing companies have slaughterhouses in Argentina, Uruguay, and Brazil; Firestone and Goodyear of Akron have rubber plantations in Liberia and Malaya; and as time goes on, other cities in the United States will engage in similar distant enterprises. The era of bargain centers is only begun.

The oil of Iran is a fine and final example. The largest oil refinery in the world stood idle for about three years. As a result, the world wondered and magnates dickered as the plant deteriorated. In November 1953 a plan was conceived. For eight months the head negotiator shuttled back and forth—New York, London, Teheran. He had an apartment in each city. He crossed the Atlantic 14 times and finally got English, American, Dutch, and French oil companies and the Iranian government into an agreement that all could sign. It provides for a half-century of operation of a more than $1-billion enterprise that will be cleared through New York, London, Amsterdam, and Paris. As a result, Iranian oil will function in the service of man, and bankrupt Iran will have income she sadly missed during the shut down.

33· Rail and Water Routes of North and South America

1. RAILWAY PATTERNS AND ROUTES OF NORTH AMERICA

Easy development of transportation and trade. North America is big, and fortunately most of it lies in the temperate zone. Its surface and contour offer easier paths for commerce than those of any other continent except Europe. North America is also rich, affording man an unrivaled volume and variety of natural resources. Hence, it is not surprising that on this continent man has made phenomenal progress in developing production, transportation, and trade.

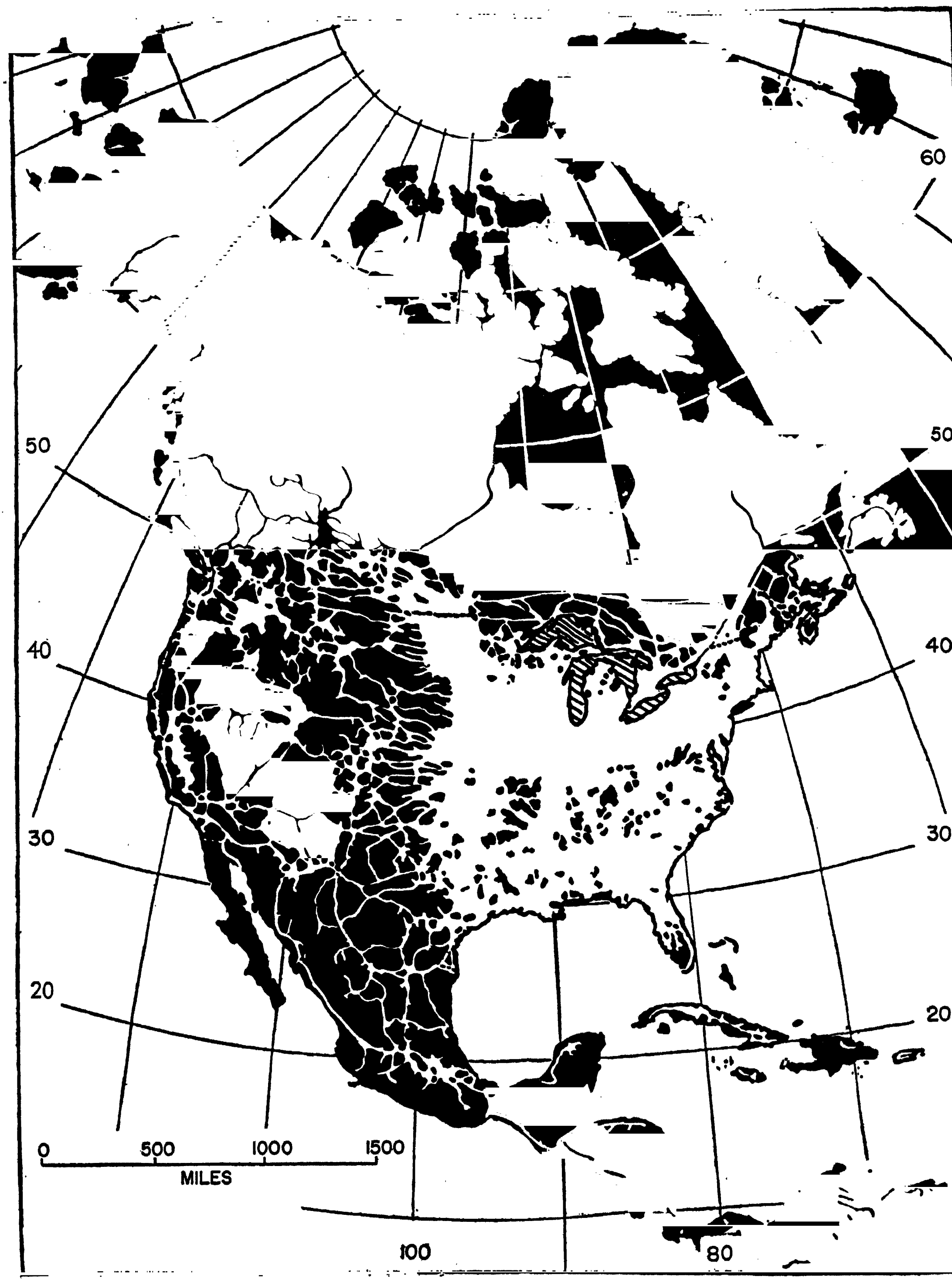
In contrast with Europe, which was already settled before the coming of the two-wheeled cart centuries ago, most of North America was opened to settlement in less than a century with the aid of steam. In the United States and Canada the building of railroads accompanied the rapid growth and westward expansion of population.[1] Railroads gave pioneer settlements easy access to markets, and most American and Canadian regions began life in a commercial era and were able to export a product or two and to buy everything needed by man. Pioneer days were characterized by regional specialization in production and the early growth of a huge internal trade.

Nowhere has man achieved greater progress in conquering space than in the United States. Our tremendous internal trade moves easily and continuously over a vast network of well-built railroads, waterways, pipelines, highways, and airways. American railroads normally haul more freight than the railroads of the Soviet Union, Germany, Great Britain, France, and Japan combined. Indeed, nearly one third of the world's railway mileage is concentrated in the United States, another third spans Europe and the Soviet Union, while the remaining third is scattered among other nations of the world.

The eastern American railweb. Few aspects of cultural environment reveal the character of an area more clearly than its railway pattern.[2] Americans have built a dense railweb from the Atlantic Coast westward to the 20-inch rainfall line (compare Fig. 580 with the annual precipitation map of the U. S., page 55). This line marks the transition from humid to semiarid climate. East of this line, ample rainfall supports a productive and diversified agriculture. Population ranges from moderate to dense. Navigable rivers are numerous. Highways and railroads are thickly spaced. In only a few areas does man have to

[1] For a concise account of the evolution and distribution of American railroads, see Ellen C. Semple and Clarence F. Jones, *American History and Its Geographic Conditions,* Houghton Mifflin Co., Boston, 1933, pp. 368–401.

[2] See Mark Jefferson, "The Civilizing Rails," *Economic Geography,* July 1928, pp. 217–231.



All land more than 10 miles from a railway is black. The railway has sharp limitations, and so does man where the railway does not go. Note sharp edge of trackless, rough land in Manitoba: the rail feeders to Magdalena River in Colombia. *Based on a copyrighted map by Mark Jefferson*

travel more than 10 miles to the nearest railroad (see Fig. 580).

The network of steel rails is thickest in the northeastern quarter of the United States. The outstanding urban, industrial, and commercial development of this section of the country gives rise to maximum density of both trackage and traffic. Within this area occurs the greatest use of multiple tracks and the most frequent operation of trains.[3] Railroads east of Chicago and St. Louis and north of the Ohio and Potomac rivers carry more than two thirds of the nation's railway passengers and nearly half of the railway freight.

Although large quantities of freight move continuously in every direction, the largest flow of traffic is eastbound. Vast shipments of food and raw materials are destined for the big industrial cities of the Atlantic seaboard and for export. Coal is the chief item of traffic. Long trainloads of Appalachian coal move steadily to Atlantic seaports, to the ports on Lake Erie, and to the inland towns and cities of eastern America.

When viewed as a whole, the freight traffic of the northeastern quarter of the United States tells a story of incoming raw materials, of outgoing manufactures, of many mouths to feed, bodies to clothe, buildings to erect, and many factories and homes to be supplied with fuel. It also reveals the location of heavy industry and the hegemony of coal and iron. In no other part of the world does so much freight move by rail.

For years New York and Chicago have been the nation's greatest traffic foci. The opening of the Erie Canal in 1825 gave New York easy access to the Middle West, a tremendous advantage over all eastern seaports. In 1853 rail service was inaugurated between New York and Chicago. Eventually the commercial dominance of New York became so great that every major east-west railroad between the St. Lawrence and the James found it profitable to extend its line or to route its traffic over other roads to New York harbor. By far the heaviest traffic in all America today is on the Pennsylvania Railroad from Pittsburgh to New York, the freight density of this transmontane route being double that of the New York Central through the Hudson-Mohawk depression.[4]

The railweb of the South is not so dense as that of the North, and it carries less than half as much freight. Most major railroads extend north and south, whereas east-west lines predominate in the rest of the nation. In spite of the rapid growth of cities and factories in recent decades, the South is primarily rural. With surplus products from forest, field, pasture, and mine, the South ships out more tons of freight than it receives.

Two broad streams of traffic flow outward from the South. Large quantities of lumber, cotton, fruits, vegetables, tobacco, livestock, coal, sulfur, and other products move by rail to markets north of the Ohio and Potomac. The second large stream of traffic flows southward to Gulf ports and thence by vessel to New England and Middle Atlantic ports or to markets overseas. New Orleans is the citadel of commerce of the lower Mississippi Valley, as it is the terminus of a long-established river traffic and of important railroads serving a large and productive hinterland. Houston (pop. 596,000) is now the largest city in the South and greatest of Gulf ports. Indeed, the outbound flow of cotton, winter wheat, petroleum, sulfur, and other products makes the combined tonnage of Houston, Port Arthur, and other Texas ports greater than that of New York (see Table 32:1).

The railnet of the West. Most of the land west of the 20-inch rainfall line is served by a sparse railnet until the Pacific slope is reached (see Fig. 580). To the west of this line, rainfall declines, and the diversified crops of the humid east give way to extensive wheat

[3] Double tracks are very common. Triple tracks are found as far west as Aurora, Ill., and as far south as Washington, D. C. The principal long stretches of four-track lines occur along the Pennsylvania Railroad from Pittsburgh to New York and along the New York Central from Cleveland to Albany. See Edward L. Ullman, "The Railroad Pattern of the United States," *The Geographical Review,* April 1949, p. 243.

[4] *Ibid.,* p. 252.

or cotton farming. Crops, in turn, soon give way to grazing, the chief use of western land.

Low rainfall and rugged topography result in large areas of sparse population and low productivity that generate little railway traffic. Nevada, Arizona, New Mexico, and Wyoming are the poorest traffic producers of the entire West,[5] and they have less than 2 miles of line per 100 square miles, the lowest railway density in the nation. Many railroads stream boldly across the Great Plains, but only seven pass the Rocky Mountain barrier and reach the Pacific Coast. Indeed, without large federal land grants and other governmental aid, many western railroads never could have been built.

Three groups of railroads form broad traffic zones between the Pacific Coast and the more populous East. In all three zones westbound traffic consists chiefly of iron and steel products, automobiles, farm machinery, and many other manufactures. Eastbound freight, chiefly raw materials and foodstuffs, exceeds westbound traffic in volume.

Three railroads span the northern zone, linking Seattle, Portland, and other cities of the Pacific Northwest with Minneapolis, St. Paul, Duluth, Milwaukee, and Chicago. Eastbound traffic includes raw silk, tea, and other Oriental products, frozen and canned fish from Alaska, apples and other deciduous fruit from the Northwest, and various agricultural, pastoral, and mineral products from the interior. The largest item of freight is lumber, which moves by the trainload from the Pacific Northwest to eastern markets.

In the central zone, the Salt Lake oasis is a major focus of routes. Two railroads extend from San Francisco to Salt Lake City and Ogden, there to meet lines coming from Portland and Los Angeles. Two railroads continue eastward across the Rockies and connect with other railroads at Denver, Pueblo, Omaha, and Kansas City. To eastern markets go products from the Northwest, fresh and canned vegetables from central California, citrus and dried fruit from California and Arizona, and beet sugar from the irrigated lands of California, Utah, and Colorado. Livestock, wool, meat, and minerals move eastward from many localities.

In the southern zone, two railroads extend eastward from Los Angeles. The Santa Fe bifurcates in New Mexico, with one branch running through Kansas City into Chicago and the other branch terminating in Houston and Galveston. The Southern Pacific follows a more southerly route via El Paso to Houston, Galveston, and New Orleans. These railroads carry minerals and pastoral products from the interior and much produce from the irrigation projects of the Southwest, such as citrus fruit, cantaloupes, dried fruit, beet sugar, beans, lettuce, and long-staple cotton.

At their eastern and western extremities, the long rail lines of the West enter lands of denser population and greater productivity. East of the Rockies, and particularly east of the ranchlands of the Great Plains, these through lines must compete with many railroads for the large traffic in wheat, cotton, cattle, hogs, and sheep. Much traffic moves within and between the Pacific states, which now have more than 15 million people. Ingot steel from Provo, Utah, and coal and metals of the Rocky Mountain states are being shipped in increasing amounts to growing industries along the West Coast.

Railroads of Alaska. Our sparsely populated Territory of Alaska has two rail tentacles extending from the seacoast into the interior. The White Pass & Yukon Railroad is only 111 miles long and connects the port of Skagway with Whitehorse, a river port in the Yukon Territory of Canada. It was built during the Klondike Gold Rush and handles little traffic today.

The Alaska Railroad is owned and operated by the United States government, and it links the coastal towns of Seward and Anchorage with Fairbanks on the Tanana, a large tributary of the Yukon. Its revenue traffic in 1953 consisted of 162,000 passengers, 937,000 tons of miscellaneous freight, and 654,000 tons of

[5] *Ibid.*, Fig. 4, p. 248.

coal. Service is maintained on 537 miles of line throughout the year, a matter of military and economic importance in the long winter months when airport runways are often hazardous and the Yukon is blocked by ice. This railroad was recently rebuilt and completely modernized.

The Canadian railnet. Canada is larger than the United States, but about 90% of Canada is forest, mountain, tundra, water, and wasteland. Nearly all Canada's 14,400,000 people live within 300 miles of the United States border. Hence, a large proportion of the Dominion is devoid of railroads, and most of southern Canada is served by a railnet much like that of our West (see Fig. 580). Maximum railway density occurs in the populous area between Quebec and Lake Huron.

Three blocks of rough and rocky terrain, producing little railway traffic, separate the principal productive areas of southern Canada. In the east the Appalachians extend to the tip of the Gaspé Peninsula, almost isolating the long-settled lands of Nova Scotia and eastern New Brunswick from those of the St. Lawrence Valley. In middle Canada about 800 miles of the glaciated, hard-rock Canadian Shield separates the cities, factories, and farms east of Lake Huron from the fertile prairies west of Winnipeg. In the west the Rocky Mountain barrier separates the prairies from the small coastal lowlands of British Columbia.

Canada is served by two great railway systems, the privately owned Canadian Pacific[6] and the government-owned Canadian National. Both span the continent from Vancouver on the Pacific to Montreal and Quebec on the St. Lawrence and to Halifax and St. John on the Atlantic. Both operate lines to U. S. ports. The Canadian National, because of political pressure, operates more lines through sparsely populated areas that produce little traffic. Thus, it serves the minor port of Prince Rupert on the Pacific and the little-used ports of Churchill and Moosonee on Hudson Bay, which is ice-bound more than nine months of the year.

The Ontario Peninsula and adjacent upper St. Lawrence Valley is a major traffic area. This land of cities, factories, and productive farms has a large movement of local freight. Its manufactures go to many parts of the Dominion. Much Appalachian coal moves into this region from the United States; pastoral products enter from the west; and lumber and ores come from the adjacent northern forest. In addition, Canadian lines north of Lake Erie carry much U. S. freight in transit from Detroit to Buffalo.

Although coal ranks first in tonnage, wheat is a more important source of railway revenue, owing to longer hauls and higher rates. The heaviest freight density in Canada occurs between Winnipeg and Port Arthur, caused by the huge movement of prairie wheat headed down the Great Lakes for domestic consumption and for export. Montreal and other St. Lawrence ports export most of Canada's wheat. These ports are closed by ice from the first of December until late in April, and during these months wheat exports move to the Atlantic ports of Canada and northeastern United States. A mere trickle of wheat is exported via Churchill. Ice-free Vancouver is Montreal's chief rival in the wheat-export trade, in spite of the rail haul over the Rockies and the long ocean voyage to Europe via Panama.

Winnipeg is the leading railway center, located a few miles south of Lakes Winnipeg and Winnipegosis. Railroads pass around these lakes through Winnipeg much as they go around Lake Michigan through Chicago. Montreal, the big eastern rail terminus, is the Canadian counterpart of New York.

The total route mileage of railroads in Canada is surpassed only by that of the United States and the Soviet Union. Canadian railroads operate 43,000 miles of line and 2500

[6] The Canadian Pacific owns profitable transatlantic and transpacific steamship lines, irrigation projects in southern Alberta, lumber mills in British Columbia, and various mining enterprises. It has long sold land to settlers from a public land grant of 25 million acres. See George P. de T. Glazebrook, *A History of Transportation in Canada,* The Ryerson Press, Toronto, 1938.

TABLE 33:1. The Population and Railroads of North and South America, 1952

Country	Population in thousands	Total miles of line[a]	Miles of line per 100 square miles
North America			
Alaska	182	567	.1
Canada	14,430	42,614[b]	1.1
Costa Rica	850	601	2.6
Cuba	5,469	3,015	6.8
Dominican Republic	2,236	152	.8
El Salvador	1,986	385	2.9
Guatemala	2,890	608	1.3
Haiti	3,200	184	1.7
Honduras	1,513	731	1.2
Jamaica	1,457	213	4.8
Mexico	26,922	12,517	1.7
Nicaragua	1,088	235	.4
Panama	841	230[c]	.8
Puerto Rico	2,240	385	11.3
Trinidad	664	123	6.5
United States	156,981	225,149	7.5
South America			
Argentina	18,056	26,915	2.5
Bolivia	3,089	1,692	.4
Brazil	54,477	21,257	.7
Chile	5,932	4,618	1.6
Colombia	11,768	1,880	.4
Ecuador	3,350	656	.4
Guiana, British	444	79	.1
Guiana, Dutch	227	107	.2
Guiana, French	29	11	.02
Paraguay	1,464	274	.2
Peru	8,864	1,962	.4
Uruguay	2,353	1,889	2.6
Venezuela	5,280	597	.2

a Route mileage available for public service, excluding multiple track, yard track, and sidings.
b Including 705 miles in Newfoundland.
c Including 51 miles in the Canal Zone.
Source: Population data from U. N., *Statistical Yearbook, 1953.* Total railway mileage data from the Association of American Railroads; *Foreign Commerce Yearbook;* and *The Statesman's Year-Book.*

miles of double track, and in 1953 they carried 156 million tons of freight. In comparison, United States railroads have 225,000 miles of line and 41,000 miles of multiple track, and they hauled 2613 million tons of freight. Minerals account for over 35% of the freight tonnage in Canada; agricultural and pastoral products, over 20%. In this country they amount to about 55% and 10% respectively.

The railroads of Mexico and Central America. The dominant fact underlying the distribution and use of Mexican railroads is the concentration of more than half of Mexico's 27 million people on the high and healthy central plateau, which occupies about one sixth of the nation's area. Agriculture on this fertile plateau has long supported a dense population. Rich silver mines have been worked for centuries. The plateau is dotted with towns and cities, the largest of which are Mexico (pop. 2,234,000) and Guadalajara (pop. 388,000). The capital city is the chief manufacturing center and market place. It is the natural hub of Mexico's sparsely developed railnet (see Fig. 580).

Railway lines radiate from the capital city to sparsely populated sections of the country and to a few seaports. They reach northward through semiarid lands to the U. S. border towns of Brownsville, Laredo, Eagle Pass, El Paso, and Nogales. At junction points between American and Mexican lines, every shipment of freight is unloaded and transferred from the freight cars of one nationality to those of the other. In contrast, passengers enjoy through Pullman-car service across the international boundary.

The City of Mexico is linked by rail with Veracruz, Tampico, and Puerto Mexico on the humid Gulf coast and with the tiny ports of Mazatlan and Guaymas on the dry west coast. No railroad links the heart of the nation with Yucatan, where three small lines converge on Progreso with henequen for export. One railroad spans the hot and humid Isthmus of Tehuantepec, connecting Salina Cruz with Puerto Mexico. This line handled a little interoceanic traffic prior to the opening of the Panama Canal, but today bananas and coffee for export are its chief items of freight.

Railroads are the main arteries of commerce in Mexico, but the life-giving stream of traffic is sluggish. Large areas are too arid, too hot and humid, or too rugged to produce much traffic. In many areas rugged topography makes railway construction, maintenance, and operation very costly. Freight rates are generally high. Manufactures and metals can stand high rates, but heavy and bulky commodities of low value seldom move

far. Cotton from the irrigated lands of the north and cane sugar from the State of Veracruz are carried to the big markets of the central plateau, but the total freight traffic in Mexico is less than 25 million tons a year.

The freight traffic of Central American railroads consists chiefly of coffee and bananas for export. Coffee is the chief export crop of the fertile and populous plateaus of the interior. It is the dominant item of freight moving down to the Pacific coast. Bananas are produced on the hot and humid Caribbean coast and, more recently, under irrigation along the Pacific. Railroads expedite the movement of millions of stems of bananas to the seaports, where vessels load the perishable cargo for rapid transport to the United States.

Although rail lines connect the Pacific with Caribbean ports in Guatemala and Costa Rica, there has never been any interoceanic traffic like that of Panama. The Panama Railroad is the oldest and shortest "transcontinental" railroad in the world. It was completed in 1855 and is only 47½ miles long. From the time it was built until it was eclipsed by the great canal, this railroad handled a lucrative transshipment trade. Today its chief service is to carry imported goods from Colón to Panama City and to move supplies within the Canal Zone.

Only El Salvador has no Caribbean coast, and only the capital of Honduras has no rail contact with the ocean. With these exceptions, the Central American republics are like identical islands in a tropic sea. Between them there is little trade. In Central America and the West Indian islands, the prime function of the railroad is to provide easy access to the sea.

2. THE INLAND WATERWAYS OF NORTH AMERICA

The significance of inland waterways. Most of North America is well supplied with waterways. A little more than a century ago, they were the main avenues of internal commerce in Canada and the United States. Traffic routes were well established along the Great Lakes, the rivers, and the canals.[7] Pioneer railway builders eagerly extended their lines from Atlantic ports to the growing towns and cities established along the rivers and the Great Lakes. Railroads served primarily as connecting links between water routes or as feeders to the waterways.

As late as 1850 waterways handled most of the freight, but by 1860 the outcome of competition between railroads and inland waterways was no longer in doubt. The railroads were able to serve vast areas beyond the reach of water transport. They offered the advantages of greater speed, direct routes without costly transshipments, and regular service throughout the year. As railroads expanded and improved their service, rail traffic increased, while that of rivers and canals declined.

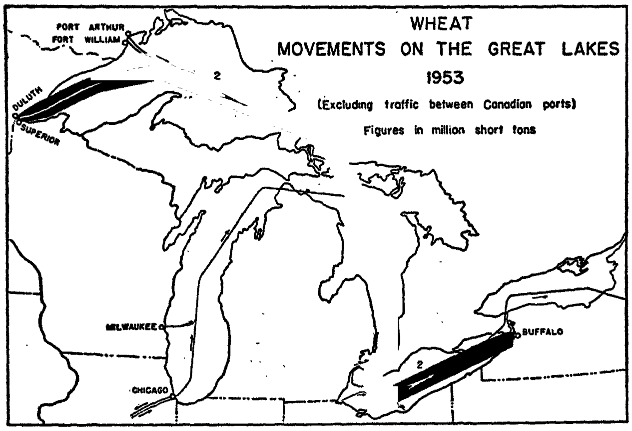
In 1953 the rivers and canals handled only 6% of the intercity freight traffic in the United States, and 10% was handled by the Great Lakes (see Table 33:2). In comparison,

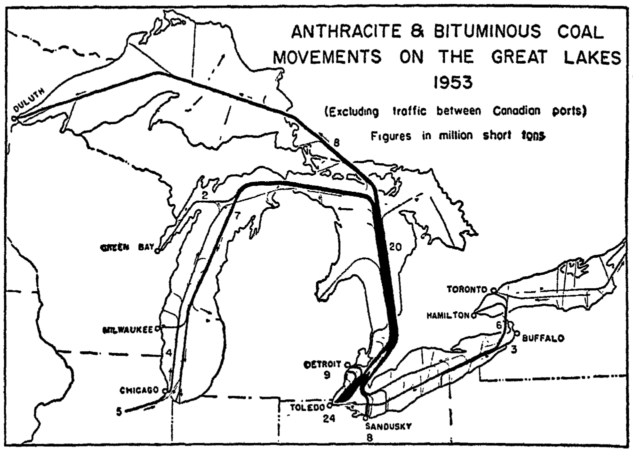
TABLE 33:2. Distribution of Commercial Traffic in the United States[a]

Agency	1930	1953
	millions of ton-miles[b]	
Steam railroads	388,500	614,000
Motor trucks	20,345	200,000
Oil pipelines	27,900	170,000
Great Lakes[c]	71,000	115,000
Rivers and canals	9,087	70,000
Electric railroads	1,148	1,000
Airlines	4	450
Total	517,984	1,170,450
	millions of passenger-miles[b]	
Steam railroads	26,876	31,800
Buses	7,080	20,500
Airlines	73	14,800
Inland waterways[d]	2,800	1,500
Electric interurban	2,400	650
Total	39,229	69,250

a Includes intercity freight traffic by private as well as contract and common carriers, except coastwise and intercoastal traffic.
b A ton-mile is the transportation of 1 ton of freight for the distance of 1 mile. A passenger-mile is the transportation of 1 passenger for the distance of 1 mile.
c United States domestic traffic only.
d Includes Great Lakes.
Source: Eastern Railroad Presidents Conference, *Yearbook of Railroad Information, 1954 edition,* New York, 1954, p. 5.

[7] See Semple and Jones, *op. cit.,* pp. 249–281.





(Left) **Traffic in wheat from Port Arthur and Fort William is 6 times that from Duluth-Superior.** ***(Right)*** **The major movement in coal is from Toledo and Sandusky to Detroit and ports on Lakes Michigan and Superior. Note also the eastward movement through Erie, Ontario, and down the St. Lawrence. Shipments of Illinois coal through Chicago are increasing in competition with Appalachian coal via Toledo. Flows of less than 50,000 tons deleted.** ***Adapted from maps prepared by U. S. Army Corps of Engineers.*** **[These maps do *not* show traffic between Canadian ports.]**

52½% of the total traffic moved by rail, 17% was handled by motor trucks, and 14½% consisted of petroleum moving through pipelines.

Today the prime function of our inland waterways is the carriage of bulk commodities that require cheap transportation rather than speed. Thus, coal is carried by barge fleets down the Monongahela River to Pittsburgh steel mills at a cost of ½¢ per ton-mile, or less than half the rate charged by railroads, while iron ore moves in large vessels down the Great Lakes for only 1/10¢ per ton-mile, which is only one tenth of the average rail rate.[8]

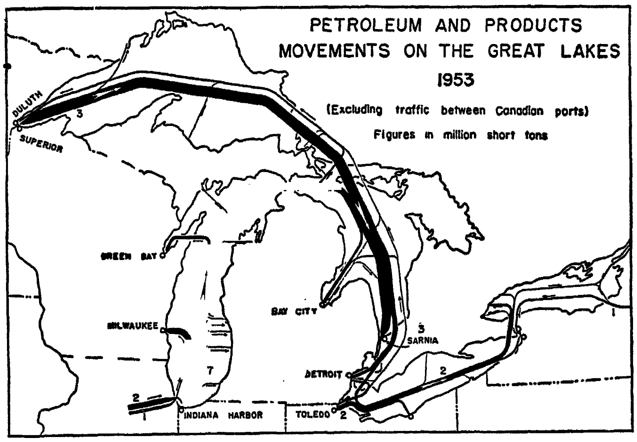
Railroads remain the backbone of the American transportation system, and they carry vast tonnages of bulk commodities, such as coal, ore, grain, and lumber. In areas served by both railroads and navigable waterways, the competition of water craft has long been a factor in forcing the railroads to reduce their rates on low-valued commodities of great weight and bulk. Today the railroad and the waterway are both competitive and complementary. It is significant that our 21 largest cities enjoy the benefits of both rail and water transportation.

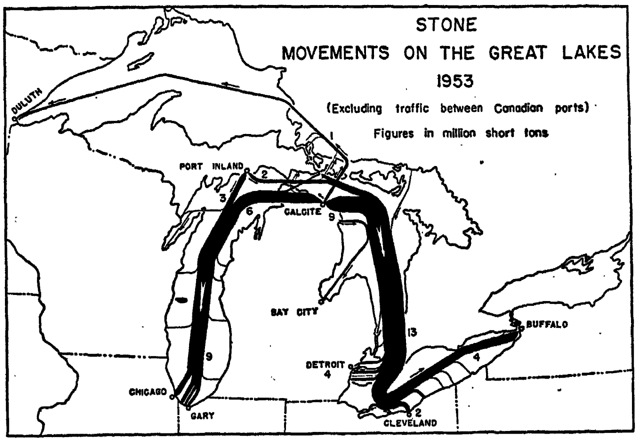
The Great Lakes. None of the world's great inland waterways can compare with the Great Lakes in volume of freight traffic. In spite of the fact that lake navigation is closed by ice for more than one third of the year, American lake ports handle about 70% as much cargo as do all our seaports combined. In most years more tons of freight pass through the St. Clair River, Lake St. Clair, and Detroit River, which link Lakes Huron and Erie, than through the Suez and Panama canals combined. The outstanding importance of the Great Lakes in the carriage of freight is a result of their large size and good location, the great bulk and weight of the principal cargoes, and the efficiency with which these cargoes are handled.

The five lakes and their connecting channels form a vast fresh-water sea of 95,000 square miles. They are well located to serve some of the most productive parts of southern Canada and northern United States. Of the world's inland bodies of water, only the Caspian Sea (area 165,000 sq. mi.) is larger, and it lies in a land cursed by aridity.

More than 95% of all lake-borne freight consists of iron ore, coal, limestone, petroleum

[8] Marvin L. Fair and Ernest W. Williams, Jr., *Economics of Transportation,* Harper & Bros., New York, 1950, p. 102. Perhaps take another look at page 358.





(Left) Notice how movement of petroleum reverses that of coal. _(Right)_ But for the Lakes, these stone quarries, which produce millions of tons each year, might be picturesque cliffs or ledges, hidden in the forest. Note the importance of lake-front steel centers as terminals for this movement. Flows of less than 50,000 tons deleted. _Adapted from maps prepared by U. S. Army Corps of Engineers._ [These maps do _not_ show traffic between Canadian ports.]

products, and grain, commodities requiring cheap transportation. Cargo tonnage (short tons) in 1953 was as follows:[9]

Iron ore	107,345,000
Bituminous coal	50,753,000
Limestone	26,999,000
Petroleum products	16,810,000
Grain	14,317,000
Anthracite coal	300,000

The amount of iron ore shipped down the lakes fluctuates with the demands of the steel industry, which is sensitive to changes in business conditions. Thus, the ore traffic amounted to only 4 million tons in the depression year of 1932, as compared with 47 millions in 1939, and an all-time record of 107 millions in 1953. Such tonnages make Duluth–Superior and Two Harbors, Minn., the world's largest shippers of iron ore.

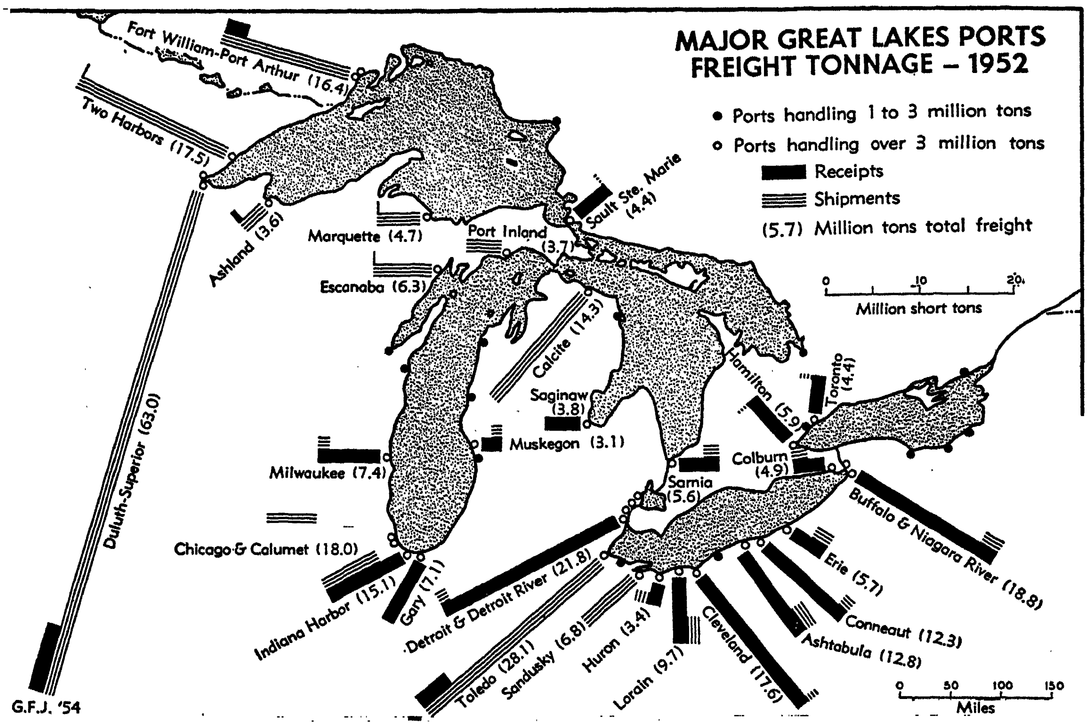
The largest movement of iron ore is destined for Lake Erie ports (see Fig. 358). Most of it is unloaded at Conneaut, Ashtabula, and Cleveland for transshipment by rail to Pittsburgh, Youngstown, and other steel centers, although a large and growing share is delivered to steel plants along the waterfront between Detroit and Buffalo. Nearly one fourth of the ore moves down Lake Michigan to the Gary–Chicago steel-making district. Only 8% of the ore goes through the Welland Canal to Canadian steel mills at Hamilton on Lake Ontario. Most of the limestone needed as flux in the furnaces of lake-front plants is shipped from the quarries at Calcite and Alpena, Mich. (see Fig. 587 right).

Appalachian bituminous coal is the one great cargo that moves up the lakes.[10] Since there is almost no competition for cargo space, it is carried at very low rates. More than 90% of all lake-borne coal is shipped from Lake Erie ports, nearly one half moving through Toledo, which since 1929 has ranked second only to Duluth–Superior in total cargo tonnage (see Fig. 588). Approximately one fourth of all coal shipped from Lake Erie ports is destined for the Detroit district, one fourth for Lake Michigan ports, and one fourth for Lake Superior, the remainder moving to ports in the Lake Huron–Georgian Bay–Sault district and along the shores of Lakes Ontario and Erie.

Petroleum is the rapidly growing infant among lake cargoes. Indiana Harbor on Lake

[9] Letter of July 26, 1954, from the Lake Carriers' Association, Cleveland, Ohio.

[10] See Albert G. Ballert, "The Great Lakes Coal Trade: Present and Future," _Economic Geography_, January 1953, pp. 48–59.



This map merits careful study.

Michigan is the principal shipper of American oil, about half of its shipments consisting of refined products. In 1950 a pipeline was completed from Albertan oil fields to Superior, Wis., and in the following year lake-borne petroleum products surpassed grain in tonnage. In 1953 the pipeline from western Canada was extended to the refineries at Sarnia, Ontario, permitting year-round delivery of oil to this section of the Dominion.

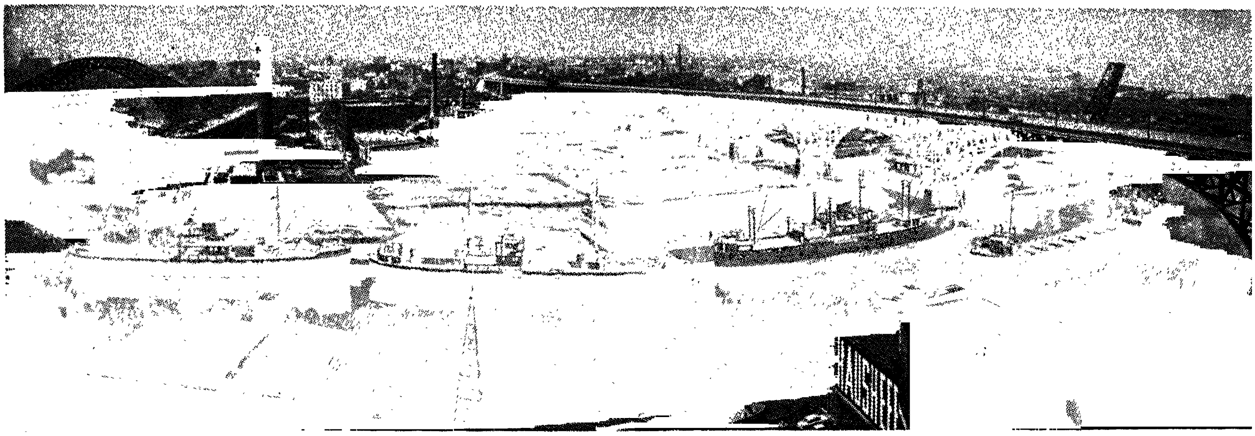
The movement of grain down the lakes is distinctly seasonal, and the amount varies with crop yields. The movement gets under way in September, but most of the grain does not arrive at lake ports before December, when harbors are closed by ice. Hence, large quantities must be stored and shipped in the following spring. The traffic in spring wheat usually exceeds that of all other grains combined.

The Great Lakes are well located to facilitate the movement of Canadian grain on its long journey from the prairie provinces to eastern markets or for export. Very little Canadian grain moves all the way east by rail. About 80% of all lake-borne grain is of Canadian origin, Fort William–Port Arthur leading all ports in the shipment of wheat, oats, and barley. Since the elevator capacity at the head of the lakes far exceeds the receiving capacity at Montreal and other St. Lawrence ports, storage en route is necessary, chiefly at Port Colborne, Kingston, Toronto, and Prescott.

The Great Lakes play a lesser role in the carriage of U. S. grain, most of which goes to Buffalo. Duluth–Superior is our chief shipper of grain. Fully two thirds of its grain trade is wheat, although it leads all lake ports in shipping rye and flaxseed. More than three fourths of all corn moves through Chicago because of its nearness to the Corn Belt.

Lake vessels. The large-scale movement of bulk commodities at low cost is achieved by the use of specially designed vessels of large capacity that can be loaded and unloaded with exceptional ease.[11] The larger ones are more than 600 feet long and about 60 to 70 feet

[11] See Alfred C. Hardy, *The Book of the Ship,* Samson Low, Marston & Co., London, 1950, pp. 247–255.



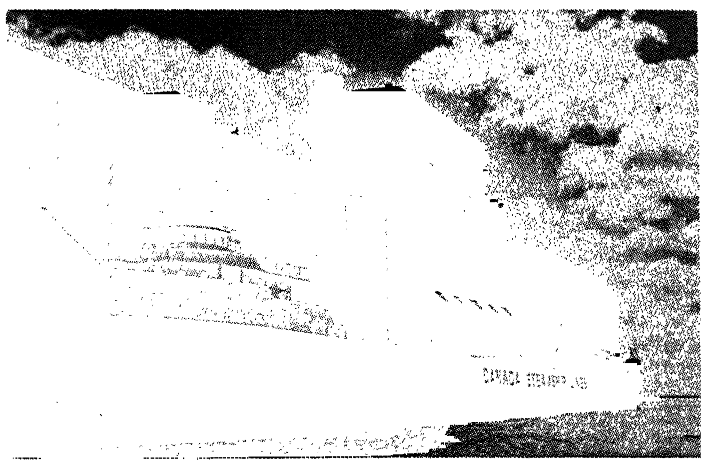
Three European ships in Cleveland harbor. Note the ore boat. ***Cleveland Plain Dealer***

wide. They can carry more than 15,000 tons of coal or iron ore or over 500,000 bushels of grain.[12] Their maximum draft is 20 feet, so that they can enter lake harbors and pass through the 21-foot dredged channel connecting Lakes Huron and Erie.

When hatch covers are pulled back, the typical freighter resembles an open barge. Loading is done by gravity—iron ore at the rate of 100 tons a minute, coal at 17 tons a minute, and wheat at 2600 bushels a minute. At the port of discharge, iron and coal are unloaded by clam-shell buckets, which reach down into the cargo hold like a human hand and scoop up as much as 20 tons at a time. The average cargo of iron ore is unloaded by a team of shovels in 3½ to 4 hours. Grain is pulled out of ships by powerful suction pipes. Oil tankers, of course, are specialized carriers that are loaded and discharged speedily by pumps. For years the rapid handling of lake cargoes has been the envy of the maritime world.

The St. Lawrence canals and the new Seaway project. The Great Lakes have three navigable outlets—the canals around the rapids of the upper St. Lawrence River, the New York State Barge Canal System, and the Illinois Waterway. All three are of shallow draft. Their combined traffic amounts to less than 35 million tons of freight a year.

The St. Lawrence canals, 14 feet deep, are too small for lake freighters and for nearly all ocean vessels that call at Montreal.[13] The canals handle about 10 million tons of freight a year, chiefly grain, coal, pulpwood, sand, and, recently, Labradorean iron ore. Most lake-borne grain destined for Montreal arrives there by rail from Lower Lake ports, only a tiny portion being carried by shallow-draft canal boats that operate as far west as Port



Lake grain carrier loading at Port Arthur. ***Port Arthur Chamber of Commerce***

[12] The *Wilfred Sykes* is a 678-foot leviathan that can carry 21,700 tons of cargo at a speed of 16 miles per hour. It cost $5 million and is owned by the Inland Steel Co. Most freighters, however, operate at a more economical speed of about 12 miles per hour.

[13] Shallow-draft vessels, carrying less than 3500 tons of cargo, are used in liner service between lake ports and Europe. See Harold M. Mayer, "Great Lakes-Overseas, An Expanding Route," *Economic Geography,* April 1954, pp. 117–143.

Colborne, the western terminus of the Welland Canal.

In May 1954 the United States agreed to join Canada in constructing new locks and canals, providing a 27-foot channel around the rapids between Ogdensburg and Montreal. A collateral project, undertaken jointly by Ontario and New York, calls for five new dams and a powerhouse to impound the turbulent waters and generate about 3,400,000 h.p. of electric energy. Together they will cost about $1 billion. In addition, vast sums will be spent to deepen lake harbors.

If all goes well, the St. Lawrence Seaway will be complete by 1960. It will permit ocean-going vessels of 26-foot draft to call at ports as far west as Toledo. It is likely that the channel between Lake Erie and Lake Huron, the St. Mary's River, and the "Soo" canals eventually will be deepened, giving Detroit and the ports on Lakes Huron, Michigan, and Superior deep-water access to the sea.

Opening the North American heartland to ocean shipping will bring significant changes in trade. Lake-front steel plants and those of the Pittsburgh district will gain easy access to the iron ores of Labrador and other foreign lands, perhaps none too soon in view of the impending depletion of Mesabi. In the movement of export grain, the final rail haul from Lower Lake ports to Montreal can be eliminated. Eventually ocean-going vessels may ascend the lakes to Fort William–Port Arthur and Duluth–Superior to secure cargoes of grain. Raw materials may enter the lakes in exchange for manufactures. All lake ports now hope for a flourishing overseas trade.

The New York Barge Canal System. The state of New York is served by a large system of canals, which are 12 feet deep and connect the Hudson River with Lakes Erie and Ontario, the Finger Lakes, and Lake Champlain. This system is the successor to the famous Erie Canal, which was opened to traffic between Buffalo and Troy in 1825, contributing to the growth of cities along its route and to the emergence of New York as the greatest of American seaports.

In spite of expensive improvements made by the state, the barge canals handle only 4 to 5 million tons of freight a year. About 75% of the traffic is westbound petroleum from New Jersey refineries, 10% is eastbound grain, and the remainder consists of such varied products as pulpwood, gravel, molasses, and Ford cars.

The Illinois Waterway. The third navigable outlet of the Great Lakes is the Illinois Waterway, connecting Lake Michigan with the Mississippi River. The waterway includes the Chicago River, the Chicago Drainage and Ship Canal, and the Des Plaines and Illinois rivers. It functions as a part of the Mississippi River system (see Fig. 591).

The Chicago Drainage and Ship Canal was built by the state of Illinois in 1909, replacing the old Illinois and Michigan Canal that had prospered in the 1850's and 1860's. In 1934 the Illinois River was canalized and dredged to a depth of 9 feet, and since then traffic has increased. The waterway handles about 18 million tons of freight a year, chiefly southbound iron and steel, northbound coal, petroleum, grain, and sulfur, and local shipments of sand, gravel, and stone.

The Mississippi River system. After a half-century of decline, traffic on the Mississippi and its tributaries was revived during World War I and has continued to grow. The volume of freight increased from 20 million tons in 1920 to 65 millions in 1938, and to 158 millions in 1952. The recent boom in river traffic was caused by the demands of World War II and the postwar rise in railway rates.

The picturesque sternwheel steamboat is almost a relic of the past.[14] It has been replaced by the integrated tow, consisting of a string of barges that fit together tightly and are pushed by a Diesel-powered towboat. Such a tow can carry 12,000 tons of freight upstream at a minimum speed of 10 miles an

[14] In 1948 the biggest sternwheeler of them all, the 276-foot *Sprague,* known to rivermen as the "Big Mama," made her last trip down the river to become a floating museum at Vicksburg, Miss. "New Life on the Mississippi," *Time,* August 30, 1948, p. 70.

hour. Many of the barge fleets are owned by large shippers of cargo, such as the oil, coal, and steel companies. Nearly 50 common carriers maintain service for the general public.[15] About 7000 barges and their towboats now ply the waters of the Mississippi River system.

Many traffic changes have occurred since the halcyon days of the sternwheeler. Cotton is no longer king of the river, package freight is generally unimportant, and the dwindling passenger service is of an excursion type. Petroleum and its products are the chief cargo, most of it moving upstream. Other major northbound cargoes are lumber, sulfur, bauxite, molasses, and scrap iron. In the downstream traffic Appalachian coal and coke predominate. Pittsburgh and Gary are large shippers of iron and steel, Minneapolis and Kansas City ship grain, and since 1948 the Ford plant at St. Louis has shipped automobiles by barge to New Orleans.

Since the first Congressional appropriation of $75,000 in 1823, the federal government has spent more than $2½ billion on deepening and improving the river and its tributaries. As a result, the Mississippi River system has 6000 miles of channels, with a minimum depth of 9 feet, available for barge traffic (see Fig. 591). On the lower Mississippi, a 35-foot channel accommodates ocean vessels as far north as Baton Rouge.

Other rivers. No section of North America is so well endowed with useful rivers as the Mississippi Valley, and nowhere has there been such a marked revival of river transportation. Traffic on the Hudson, Tombigbee-Warrior, and Columbia-Willamette systems has increased slowly. The deep St. Lawrence is of primary importance to ocean shipping. Only a few shallow-draft steamers navigate the mighty Yukon during the three summer months. The long Canadian rivers meandering northward to the Arctic Ocean are but lonely trails for birchbark canoes in summer, and in

See what a commanding economic location—north from New York and around to St. Paul and Brownsville. ***From M. L. Fair and E. W. Williams, Economics of Transportation, Harper & Bros., 1950***

the long cold winter they are frozen highways for a few dog sleds and tractor trains.[16]

3. THE RAILROADS OF SOUTH AMERICA

Environmental barriers to trade. The development of transportation and trade in South America is subject to serious topographic and climatic handicaps. South America is poorly endowed with natural harbors, and a mountain wall surrounds the greater part of the continent. The lofty Andes extend from the Caribbean southward along the Pacific coast to the Strait of Magellan. On the east coast, the highlands of Venezuela, the Guianas, and Brazil impede access to the interior. The great Amazon and Orinoco river systems drain vast but almost empty tropic lowlands, and only the lower Paraná gives access to temperate and fertile plains.

[15] One line has 24 towboats and 480 barges, including covered barges for general cargo. See "Mississippi Valley Barge Line Company," *World Ports,* May 1954, pp. 30–32.

[16] See J. Russell Smith and M. Ogden Phillips, *North America,* Harcourt, Brace & Co., New York. 1942, pp. 256–258.

Note dense railweb in Argentina and incipient web in Brazil. Elsewhere, chiefly tentacles extending from the sea. *Based on copyrighted map by Mark Jefferson*

Three fourths of South America lies in the torrid zone, and in this vast area most people live in the highlands to escape tropic heat. Thus, most Brazilians live on the rolling uplands of eastern and southern Brazil, while the peoples of tropic Andean countries are concentrated in mountain valleys and on high plateaus. Only one third of the people of South America live on plains less than 1000 feet in elevation, notably the temperate fertile lands of Argentina, Uruguay, and central Chile. With few exceptions, the major concentrations of population have developed around the periphery of the continent not far from the sea. The commercial life of the continent generally passes along a few short routes connecting centers of population with nearby seaports.[17] The ocean is South America's chief highway.

Railway development in Argentina and Uruguay. The outstanding progress and prosperity of Argentina, Uruguay, Brazil, and Chile is revealed by the concentration of 88% of the continent's railway mileage in these four countries. Maximum railway development occurs on the fertile Argentine pampa, where a dense railweb fringed by a railnet covers about 100,000 square miles, extending westward from the Atlantic coast to a frontier of aridity, about 64°W. Long. (see Fig. 592).

Although the pampa occupies less than one fourth of the nation's area, it contains three fourths of Argentina's 18 million people, four fifths of the cultivated land, three fourths of all manufacturing, and three fourths of all railway mileage. All major railway systems and their traffic in grain and animal products focus upon the great port and capital city of Buenos Aires (pop. 3,000,000), with Rosario, Santa Fé, and Bahia Blanca as secondary ports.

Elsewhere in Argentina railway density is low. Rail tentacles extend northward into the Chaco lands of cotton and quebracho and westward to the irrigated oases near the foot of the Andes, while in bleak Patagonia only two lines reach inland from the sea. Buenos Aires is now linked by rail with the capital of every neighboring nation, but international traffic is small. Railroads mean much to Argentina. Outside the province of Buenos Aires the highways are poor, and it often costs more to move grain from the farm to the nearest railway station than to ship it from Buenos Aires to Liverpool.[18]

Highways are also poor in wealthy, pastoral Uruguay, which depends upon railroads that radiate from Montevideo. As in Argentina, the tonnage of freight for export far exceeds inbound traffic. Unlike Argentina, all Uruguayan lines are of standard gauge, or 4 feet 8½

[17] For a discussion of the population pattern and its significance, see Preston E. James, *Latin America*, The Odyssey Press, New York, 1950, pp. 5–10.

[18] Ray H. Whitbeck and Frank E. Williams, *Economic Geography of South America*, McGraw-Hill Book Co., New York, 1940, p. 233.

andean Railroad, linking Valparaiso with Buenos Aires, carries little freight and has lost most of its passenger traffic to the airplane. In the north, Arica and Antofagasta are coastal termini of railroads carrying tin and other metals from landlocked Bolivia. In 1948 a new line was completed between Antofagasta and Salta, permitting the exchange of Chilean nitrate and copper for Argentine grain, vegetables, and beef.

The tentacular development of Andean railroads. Throughout the Andean countries north of Chile, railway development has been meager and usually very expensive. Most lines are tentacles reaching inland from the sea. Some reach the high, temperate, and populous basins and plateaus of the interior. Few lines that climb the lofty Andes have enough traffic to pay operating costs and interest on the original investment. Highways are rare, and in rugged areas the sure-footed burro is an indispensable adjunct to the railroad.

In Peru numerous short railroads carry cotton, sugar, and other irrigated crops of the coastal desert to nearby ports. Only two long rail tentacles penetrate the cordillera. One line extends from Callao through Lima up to the plateau and southward to Huancayo. It was built at a cost of $220,000 per mile and with the loss of 7500 lives. For miles the standard-gauge track follows a narrow shelf cut in the rock wall of the Rimac canyon. As it climbs to an elevation of 15,665 feet, the railroad has 67 bridges, 65 tunnels, and 16 switchbacks. On the plateau it is joined by a line from the north that taps the rich Cerro de Pasco mining district. Traffic consists of grain shipments from the Huancayo Basin to Lima, and exports of lead, zinc, copper, vanadium, silver, and gold.

In southern Peru another rail tentacle penetrates the interior, a costly line that links the ports of Mollendo and Matarani with the town of Puno on the shore of Lake Titicaca, 12,535 feet above sea level. Steamboat service connects Puno with the Bolivian town of Guaqui, head of the Bolivia & Antofagasta Railroad. A northern extension of the line reaches the city of Cuzco, ancient capital of the Incas. As on all Andean lines, freight rates are high.[19] Wool is now the chief commodity moving down to the coast for export.

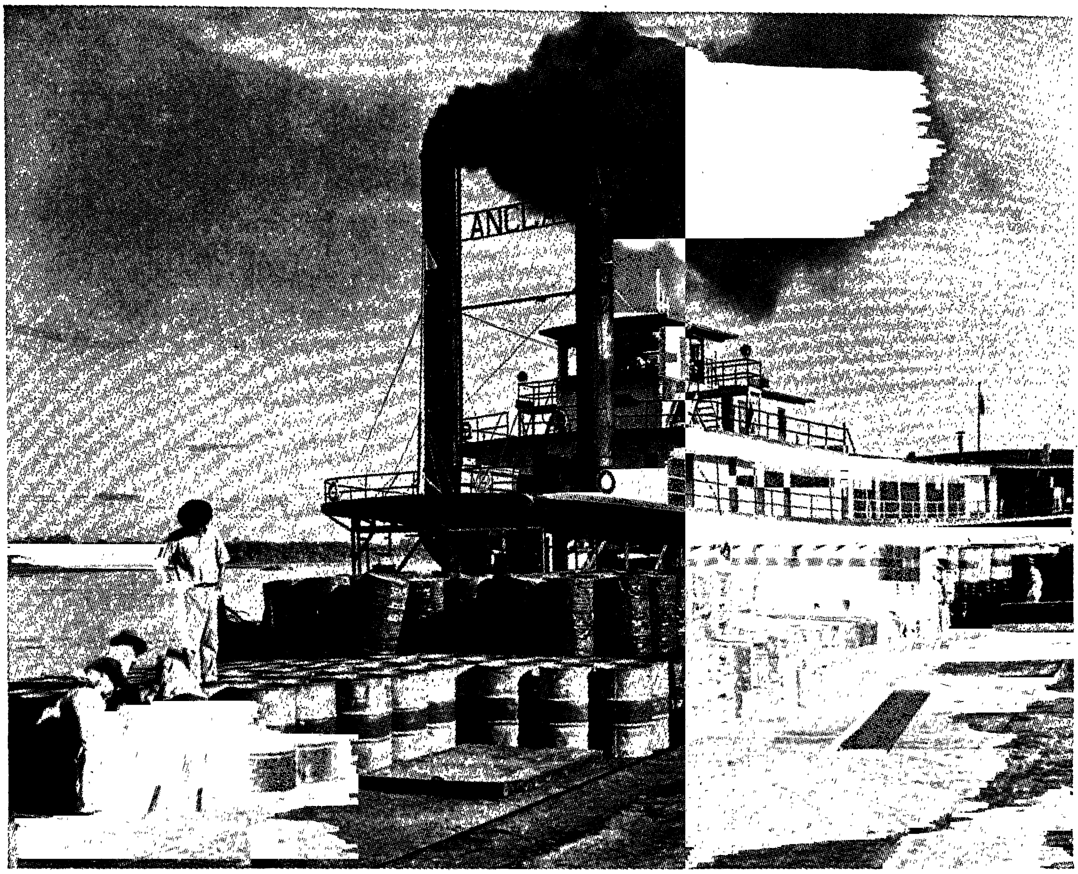
Bolivian exports consist of tin, zinc, lead, silver, and other metals, most of which now leave the country by the short Arica-La Paz route. Bolivia is the only country north of Chile with rail access to transandean lands. One line extends through Cochabamba to Cliza, deep in the Yungas, the garden spot of the nation. This railroad carries a variety of temperate-zone and subtropical foodstuffs to the cities and mining towns on the cool and dry plateau. In January 1955 a railway line was completed from Santa Cruz to Corumbá, linking eastern Bolivia with the Brazilian railway system.

Cacao, bananas, and coffee dominate the Ecuadorean export trade. These are produced along or near the coast, and the 250-mile Guayaquil-Quito line carries only small amounts of highland wool, hides, and gold. Coffee is the big export crop of Colombia, where rail tentacles extend from the Magdalena River and the Pacific port of Buenaventura to population centers and coffee-growing areas in the highland interior. Bogotá, Colombia's capital and chief city, has no rail contact with the sea. Venezuela is fortunate that her populous highlands are near the Caribbean. Venezuelan coffee and other highland exports have short hauls to the ports of Tucacas, Puerto Cabello, and La Guairá.

4. THE RIVERS OF SOUTH AMERICA

The Magdalena River. No South American country is so dependent upon river transportation as Colombia. Most of Colombia lives in an age of waterways like that of our Mississippi Valley in 1840–50. With the exception of air-borne passengers, mail, and high-valued

[19] Some years ago the cost of producing tin concentrates in Bolivia was $7.13 per ton, the railway freight to Mollendo amounted to $46.02 per ton, while the ocean freight from Mollendo to Europe was only $7.80. *Ibid.*, p. 159.



Barrancabermeja, Colombia—charter boat of the Tropical Oil Co., which hauls petroleum products on the Magdalena River. ***Standard Oil Co. (N. J.)***

freight, nearly all traffic to and from the highland heart of Colombia is handled by sternwheel steamers on the Magdalena River.

The port of Barranquilla, 10 miles above the mouth of the river, is Colombia's great gateway of commerce, and coffee is the leading commodity that moves downstream for export. Nearly all the coffee is grown on the slopes of the central and eastern cordillera. Short rail lines carry it to little ports along the river. Thus, the coffee of the Medellin district is shipped to Puerto Berrio; the coffee of Bogotá, to Giradot; Ocaña coffee, to Puerto Nacional; and Bucaramanga coffee, to Puerto Wilches. Although Manizales is now linked by rail with the Pacific port of Buenaventura, some of its coffee is shipped on a cable line over the central cordillera to Fresno on the river. In addition to coffee for export, river steamers carry highland grain and potatoes to the lowlands, while upstream traffic includes cotton, sugar, and cattle from the lowlands and a great variety of manufactures from overseas.

Although the Magdalena River is navigable for more than 900 miles, it is seriously handicapped by sandbars, a fluctuating depth, shifting channels, rapids, and costly transshipments. Only for 70 miles above the delta is the river navigable at all times of the year. The movement of freight between Barranquilla and Bogotá may be accomplished in less than 2 weeks; but when the river is low, steamers get stuck in the mud, and goods may be 4 or 5 months in transit.

No capital city in the New World is so difficult to reach, except by airplane, as Bogotá. Inbound freight is transferred from the ocean vessel at Barranquilla to a river

steamer that carries it 615 miles upstream to La Dorada, where the freight is transshipped by rail around the rapids and then reloaded on a shallow-draft steamer. At Giradot the freight is unloaded and put on a train, but halfway to Bogotá the railway gauge changes, and all goods must be transferred from one train to another. It is not surprising that transportation costs and numerous handling charges cause the value of imports to be doubled or trebled between the seaport and the capital city. In Colombia, "Ole Man River" is a costly tune!

Attempts have been made to by-pass the exasperating Magdalena. Some river traffic above the rapids has been diverted to the railroad that runs along the river from Honda to Neiva, the head of navigation. Bogotá now has access to Buenaventura by a route that extends westward by rail to Armenia, thence by a 50-mile highway through the lofty Quindio Pass in the central cordillera to Ibagué, and on by rail through the Cauca valley and over the western cordillera to the Pacific coast. Buenaventura today is congested with traffic and rivals Barranquilla. The side-door entrance to Colombia may prove to be more important than the front door.

The Orinoco. Unlike the Magdalena, the Orinoco was long a river of minor commercial importance, for it drains the llanos of Venezuela and eastern Colombia, a sparsely populated grazing region. For 1500 miles the Orinoco is navigable by steamers drawing 12 feet of water, and in the wet season boats can ascend the river into Colombia. The largest city in the Orinoco Basin is Ciudad Bolivar (pop. 20,000), about 230 miles from the mouth of the river. It is the trading center for the llanos and adjacent Guiana highlands. Hides and small amounts of gold, balata, and tonka beans are assembled at Ciudad Bolivar and are carried by steamers to Port-of-Spain, Trinidad, for transshipment to foreign markets.

In 1951 the Bethlehem Steel Corp. began shipping iron ore from its mines at El Pao, which are located about 40 miles south of Palua, a small port at the junction of the Orinoco and Caroni rivers. The iron ore moves by rail to Palua and by barge downstream and across the Gulf of Paria to Puerto Hierro, a newly constructed port on the Paria Peninsula. Ocean vessels carry the ore to the Bethlehem steel plant at Sparrows Point, Md.

In 1954 the United States Steel Corp. began shipment of iron ore from its huge deposit at Cerro Bolivar to steel plants at Morrisville, Pa., and Birmingham, Ala. Ore moves a short distance by rail from the mines to Puerto Ordaz on the Orinoco and is loaded into ocean-going vessels, which travel 154 miles downstream through a newly dredged 26-foot channel to the Caribbean.

The Amazon River system. In many ways the Amazon is an amazing river. The main stream and its tributaries provide about 50,000 miles of navigable water. For 1000 miles in its lower course, the Amazon has an average depth of over 100 feet. In its last 2000 miles the Amazon descends only 35 feet, or 2/10th inch per mile, and large areas are flooded during high water. Ocean vessels regularly ascend the river to Manaus, a distance of 1000 miles, and large boats navigate to Iquitos, Peru, 2300 miles from the sea. Steamers are able to navigate the major tributaries for 500 to 1000 miles, but many a river is given over to the lonely native in his dugout canoe and to the crocodile.

About 2 million square miles of Brazil, Bolivia, Peru, and Colombia depend upon this gigantic river system for transportation. The chief ports are Belém (pop. 165,000) near the mouth, Manaus (pop. 67,000), and Iquitos (pop. 34,000), but the Amazon Basin as a whole is a hot, humid, empty area with less than 1 person per square mile. In this region of large potential food-producing capacity, many settlements must import not only manufactures but also food. Downstream traffic consists of forest products—chiefly rubber, Brazil nuts, babassú nuts, tagua nuts, balata, and hardwoods. The total exports are worth less than $35 million a year, a small sum for such a big region.

The Plata-Paraná-Paraguay waterway. The Rio de la Plata and the Paraná-Paraguay river system comprise the busiest waterway in South America. Through the Plata estuary flows a huge overseas trade. Buenos Aires and Montevideo are the great gateways for the foreign commerce of Argentina and Uruguay. They serve as transshipping points for the overseas trade of Paraguay and a part of southern Brazil and Bolivia. Furthermore, these two big cities are major markets for many of the commodities that move downstream.

The Plata-Paraná-Paraguay route extends for 1700 miles from Buenos Aires to Corumbá, Brazil. Ocean vessels regularly ascend the Paraná to Rosario and Santa Fé to load cargoes of grain and meat destined for Europe. Some 4000 river steamers call at Asunción, Paraguay, each year. Steamers drawing 12 feet of water navigate the Paraná and Paraguay as far north as Concepción, 180 miles above Asunción, and smaller vessels call at Corumbá throughout the year. On the other hand, the upper Paraná is a less useful stream. Although it is navigable from Corrientes to Puerto Aguirre, at the mouth of the Iguassú River, it traverses a very sparsely populated country and has little traffic above the Paraguayan town of Encarnación. 27°S, 56°W.

Downstream traffic on the Plata-Paraná-Paraguay route consists of pine lumber, hides, meat, cotton and cottonseed cake, tobacco, yerba maté, coconut oil, petitgrain oil, and Brazilian manganese and iron ore. The volume of commodities moving downstream is much greater than the upstream movement of manufactures, and this unbalanced traffic tends to make freight rates high. Although it often costs more to ship products 1000 miles from Asunción to Buenos Aires than from Buenos Aires to Europe, the waterway remains the great avenue of commerce for this section of the continent.

34· Rail and Water Routes of Eurasia, Africa, and Australasia

1. THE RAILROADS AND WATERWAYS OF EUROPE

Europe's unusual advantages for trade. The normal peacetime trade of the different European countries is huge and closely resembles the trade of temperate North America. Each of these continents has, in the region of middle temperature, facing the Atlantic, a large territory with tens of millions of manufacturing people buying food and raw materials.

In America the great manufacturing region is bounded by a line connecting St. Louis, Milwaukee, Montreal, Portland, and Baltimore, and extending back to St. Louis. In Europe the manufacturing belt extends from Stockholm, Budapest, and Florence westward to the Atlantic, including Great Britain, the home of the factory system. In the interior of Europe and North America lie the grain- and meat-producing plains. In the north are water power and forests with their wood and paper output; in the south, the land of subtropic fruits and early vegetables. Europe has only a small Corn Belt and almost no vestige of a Cotton Belt, but has instead a great extent of potato, barley, oats, and rye belts in her mid-region (see folded map at front of book).

In the natural ease of her exchange of foods and raw materials for manufactures, little Europe has been favored more than any other continent. Irregular coastlines make short and easy communications between the interior and the sea—the cheapest of all highways. Here Europe is supreme. Africa and South America resemble solid blocks. Even the United States, with its favorable location, its splendid routes, and an area nearly equal to that of Europe, has but 5200 miles of seacoast, while Europe has 20,000. Hence, it is natural that the greatest trade routes of Europe should be water routes.

Trade is also favored by the location of the inland seas that indent the European coast. The Mediterranean and the Black Sea extend the advantage of the ocean 50° eastward from western Spain. Although the Baltic Sea cannot compare with the Mediterranean and the little North Sea in commercial importance, it affords the advantage of cheap ocean transportation for one corner of the continent.[1] Between the northern and southern seas Europe is but a great peninsula, fringed with a succession of smaller peninsulas. For commercially advantageous location, Greece, Italy, Iberia, Scandinavia, and Denmark fall but

[1] See W. O. Blanchard, "The Baltic Sea—Commercial Blind Alley," *Journal of Geography*, February 1944, pp. 62–70, and "The World's Greatest Inland Sea—the Mediterranean," September 1950, pp. 232–238.

little below so many islands. France faces two seas, European Russia faces three, and Britain is an island kingdom. Furthermore, Europe has no large isolated plateaus, and it is well supplied with navigable rivers. The pronounced climatic and economic differences between various sections of the continent have long been the basis for trade.

Man-made barriers are the principal obstacles to the growth of intra-European trade. The division of the continent into many countries, each with its tariff wall, stands in contrast to the absence of tariff barriers between the 48 American states. Since World War I, every European nation has followed a protective tariff policy. The Schuman Plan has created a common market free of tariff barriers for the coal, coke, iron ore, and steel of six western European countries, but only little Belgium and Luxembourg have had the good sense to establish a customs union permitting the free flow of all commodities. Following World War II, the creation of an "Iron Curtain" separating communist countries from the rest of Europe has greatly reduced trade between these big sections of the continent (see Table 34:1).

The western European railweb. From the beginning, railway construction was easy on the plains of Europe. In most of Europe mountain ranges are low and were soon crossed by easy windings through mountain passes or by the use of short tunnels. Only the Alps, Pyrenees, and Apennines presented serious engineering difficulties, and the tunnels needed to establish routes through these mountains cost years of hard work and many millions of dollars.[2] Even the Strait of Dover and the Baltic Sea eventually were spanned by seagoing ferryboats carrying railway trains.

Eastward from the Atlantic man has built a dense railweb covering an area of ¾ million square miles and inhabited by some 270 millions of people (see Fig. 600). This railweb covers virtually all the British Isles, France, Belgium, Luxembourg, the Netherlands, Denmark, Germany, Czechoslovakia, Austria, Hungary, most of Italy, and the more densely populated sections of Norway, Sweden, Poland, and Yugoslavia.

For the most part, this closely woven fabric of steel rails serves modern, mechanized Europe—a land of big cities and factories, intensive agriculture, and, in normal times, a land with a large internal and external trade (see Figs. 34 and 371). No point is more than 10 miles from a railroad. Waterways, highways, and airways are well developed. Railway lines are thickest in Belgium, the United Kingdom, Switzerland, Germany, and France, and most European countries have a larger percentage of double track than the United States. More than a dozen European nations surpass the United States in railway density.

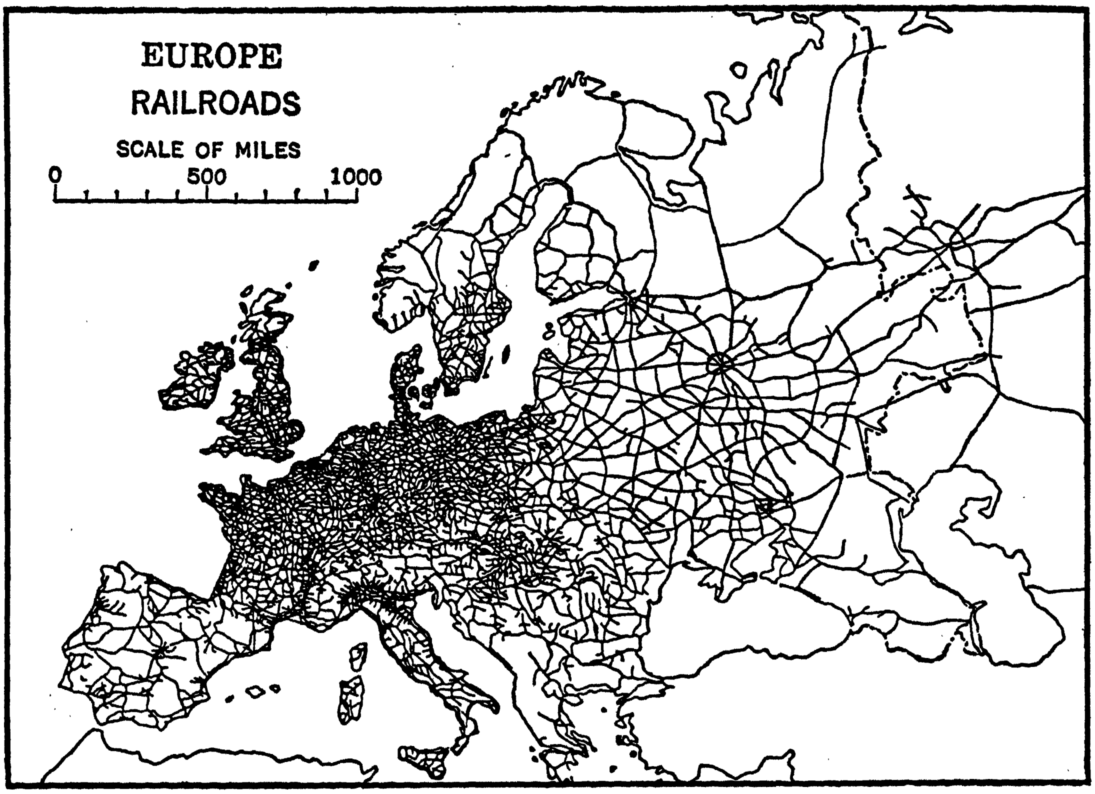
In Europe the railroads are the major carriers of manufactures and perishable foodstuffs, and they handle many other items of freight. In the industrial areas they have a

TABLE 34:1. West Europe's Net Import of Food Products from East Europe[a]
(thousands of metric tons)

Foodstuff	Prewar[b]	1952
Total grains	5600	2240
Wheat and rye	3200	750
Other	2400	1490
Potatoes	1300	7
Sugar	775	275
Meat	200	72
Eggs	20	25
Dry legumes	c	5
Other vegetables	c	20

a East Europe includes the Soviet Union, Poland, East Germany, Czechoslovakia, Hungary, Rumania, Bulgaria, Albania, Yugoslavia, and Finland. (All except Finland and Yugoslavia are behind the Iron Curtain.)
b A 4- or 5-year average within the period 1933–39.
c Exports to East Europe exceeded imports.
Source: Lois Bacon, "Europe's East-West Trade in Food," *Foreign Agriculture*, July 1954, p. 131.

[2] The 9-mile St. Gotthard Tunnel in the Swiss Alps, opening a rail route between Berlin and Milan, was completed in 1882 after 10 years of labor and an expenditure of $23 million. Other famous Alpine tunnels include the Simplon, Arlberg, Wasserflu, Lütschberg, Mont d'Or, Mont Cenis, and Nice-Cuneo. In 1930 a tunnel, 11.3 miles long and costing $100 million, was completed in Italy under the Etruscan Apennines along the route between Florence and Bologna.



Europe is a good continent in many ways, especially in opportunity for water transport. Rails are but feeders to the main trunk, the seas. See Alps, Po Valley, mountains of Yugoslavia, Albania, Greece. ***Adapted from S. VanValkenburg and C. Held, Europe, John Wiley & Sons, 1952***

large short-haul traffic in coal and iron. In Europe, however, railroads obtain a smaller share of the total freight traffic than in the United States, because large quantities of bulky and low-valued commodities are shipped by coastwise vessels or by the barges that ply the inland waterways. On the other hand, the railroads of Europe surpass American railroads in the volume and relative importance of their passenger traffic. In European countries the passenger car, bus, and motor truck are not such serious competitors of the railroad, for in Europe, including the Soviet Union, there are 39 persons per motor vehicle as compared with 3 persons in the United States (see Tables 26:1 and 34:2).

In normal times international trains make long runs in many directions. Paris is probably the greatest railway center of Europe, but London may be considered as the western terminus of the main transcontinental railway routes. Several days after an ocean liner has cleared Great Britain for the Orient, passengers, mail, and express can leave London and and travel by rail via Paris and Milan to the port of Brindisi in southern Italy and board the ship when it calls there en route to the Suez Canal. Other important transcontinental railway routes are those connecting Paris, Berlin, Warsaw, and Moscow; Paris, Milan, Belgrade, and Istanbul; and Berlin, Vienna, Belgrade, and Istanbul. As long as tariffs and other man-made barriers remain, these transcontinental railway routes can never function as effectively as those that span the United States.

The railnet of peripheral Europe. Beyond the railweb of western Europe lies little mechanized, rural, peripheral Europe, a land where agriculture generally dominates the life of man and where wealth and purchasing power are low. In large areas of peripheral

TABLE 34:2. The Population and Railroads of Europe and Asia, 1952

Country	Population (millions)	Total miles of line[a]	Miles of line per 100 square miles
Europe			
Albania	1.2	26	.2
Austria	6.9	3,698	11.4
Belgium	8.7	3,119	26.5
Bulgaria	7.4	2,224[b]	5.6[b]
Czechoslovakia	12.3	8,092	16.5
Denmark	4.3	2,263	13.6
Eire (Ireland)	2.9	2,463	9.1
Finland	4.1	3,140	2.6
France	42.6	25,105	11.8
Germany, East	17.3	7,500	18.1
Germany, West	48.5	18,935	20.0
Greece	7.8	1,665	3.2
Hungary	9.5	5,173[b]	14.4[b]
Italy	46.9	13,441	11.6
Luxembourg	.3	332	3.3
Netherlands	10.4	2,006	15.6
Norway	3.3	2,700	2.2
Poland	25.0	13,128	10.9
Portugal	8.5	2,102	5.9
Rumania	16.3	7,363[b]	6.5[b]
Spain	28.3	10,563	5.5
Sweden	7.1	10,518	6.1
Switzerland	4.8	3,345	21.0
United Kingdom	50.4	20,617	21.9
U. S. S. R.	193.0[c]	57,487[c]	.7[c]
Yugoslavia	16.7	6,926[b]	7.2[b]
Asia			
Afghanistan	12.0	0	.0
Burma	18.9	1,739	.7
Ceylon	7.9	913	3.6
China	463.5	20,781[d]	.6[d]
India and Pakistan	442.8	40,861	2.6
Indochina	27.0	1,836	.6
Indonesia (Neth. E. Indies)	78.2	4,536	.6
Iran (Persia)	19.6	1,533	.2
Iraq (Mesopotamia)	5.1	966	.8
Japan	85.5	10,471	7.1
Korea	25.1	2,101	2.5
Malaya and Singapore	6.5	1,068	2.1
Palestine (including Israel)	1.7	626	6.0
Philippines	20.6	843	.7
Saudi Arabia	7.0	350	.04
Syria	3.4	516	.8
Thailand (Siam)	19.2	2,126	1.1
Turkey	22.0	4,672[e]	1.6[e]

[a] Route mileage available for public service, excluding multiple track, yard track, and sidings.
[b] Data and boundaries as of 1937.
[c] Includes European and Asiatic Russia; population as of 1947.
[d] Includes 5381 miles in Manchuria and 2440 miles in Formosa.
[e] Includes 210 miles in European Turkey.

Compare this table with Tables 33:1 and 34:3.

Source: Population data from United Nations, *Statistical Yearbook, 1953*, and *The World Almanac and Book of Facts for 1954*. Total railway mileage data from the Association of American Railroads and U. S. Dept. of Commerce, *Foreign Commerce Yearbook, 1951*.

Europe, man must travel 20 to 50 miles and sometimes farther to the nearest railroad (see Fig. 600), and he is often dependent upon slow and primitive means of transportation. Here the mobility of man is low (see Tables 26:1 and 34:2).

Man is served by a sparse railnet throughout the Iberian peninsula, the Balkan countries, nearly all of Norway, northern Sweden and Finland, eastern Poland, and in large areas of the Soviet Union. Railway density is at a minimum in Albania, which had no railroads until 1947, when a 26-mile line was built inland from the port of Durazzo. Elsewhere railway density is lowest in rugged, maritime Norway and in the rough and backward Balkans, but even here the number of miles of line per 100 square miles is greater than in our sparsely populated western states of Arizona, Nevada, Wyoming, and Utah.

Within the area covered by the railnet, rainfall varies from less than 10 to more than 80 inches. The dry and rugged Spanish plateau is the only area west of Russia where aridity is a major factor underlying sparse railway development. In the Far North arctic cold is an obvious handicap to progress. Elsewhere in peripheral Europe, excepting Russia, low railway density is primarily the result of rugged topography or of such human factors as unfavorable political, economic, and social conditions.

The principal function of the European railnet is to handle local traffic and to expedite the movement of heavy and bulky exports to the seacoast. Such exports as Balkan grain, Italian fruit and wine, Spanish oranges, Portugese cork, Norwegian lumber, Swedish iron ore and wood pulp, and Finnish forest and dairy products are dependent upon ocean transportation to reach their leading foreign markets. Most of peripheral Europe looks toward the sea.

Major water routes. The irregular shape of the European continent stimulates coastal traffic, and the large areas of flat terrain facilitate the improvement and use of inland waterways. Landlocked Switzerland, Czechoslovakia, Austria, and Hungary have navigable rivers leading to the ocean highway, and all other nations adjoin the sea.

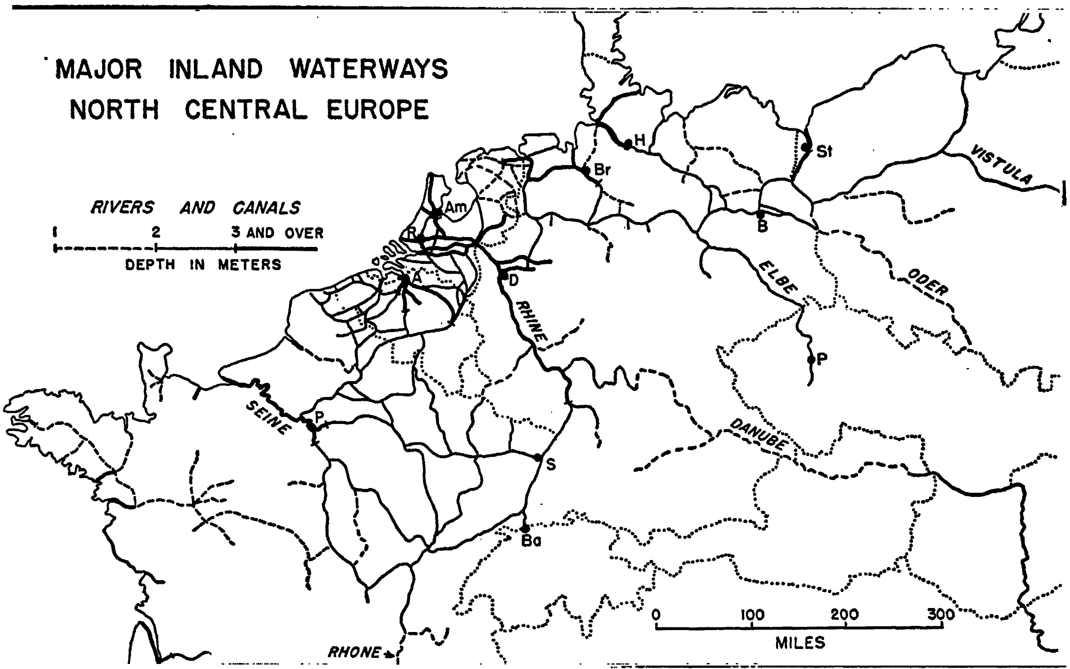
The southern heavy traffic route reaches from the North Sea to the eastern Mediterranean and Black seas. This route is poor in branches that navigable rivers furnish. In the Mediterranean are the Ebro and Po, of third-rate importance, and the second-class Rhône. The Black Sea has the Russian-controlled Danube, Dneiper, and Don. Mud-choked mouths are the characteristic of the rivers flowing into these tideless seas.

From the Mediterranean iron ore, petroleum, cotton, phosphates, and foodstuffs move to northwestern Europe in exchange for manufactured goods and coal. There is a similar trade within the Mediterranean between the raw-material importing countries (France and Italy) and the food and raw-material exporters along the eastern and southern shores.

The second major route extends from the North Sea into the Baltic with a branch around the coast of Norway to the White Sea and the rivers of western Siberia. This route serves a more highly developed area and is favored by receiving more navigable branches than its southern counterpart. Iron ore and manufactured goods from Sweden; timber from Scandinavia, Finland, and (politics permitting) the Soviet Union; fish from Norway, and foodstuffs from several areas are major items in this complicated exchange with the industrial coal-exporters around the English Channel.

The highly industrialized and mineral-rich area on both sides of the English Channel is the major focus and point of origin for much of this peripheral European sea traffic.

Water transport on the North European plain. Major rivers and interconnecting canals provide the plain of northern Europe with a unique system of inland water transport. The Rhine, key to this system, is the greatest of European inland waterways. It serves the rich Westphalian coal field and the highly industrialized Ruhr. It continues through a productive valley to the head of navigation at Basle,



Rivers of great European plain linked by canal network. Especially dense both sides of Rhine estuary. Initials for ports. Nothing like this in the United States. ***Adapted from U. S. Department of State Map No. 10110, 1946***

Switzerland, 513 miles from the North Sea. Navigation is facilitated by the river's gentle gradient, its relatively uniform flow, and the many improvments made during the centuries this waterway has been in use. Indeed, navigation is interrupted only 8 days of the year by high water, 17 low water, and 17 days by ice.

The largest tonnage moves along the stretch downstream from the Ruhr, navigable for ocean vessels carrying up to 4000 tons, although most of the traffic is in barges of 2000- to 2500-ton capacity. In 1938, the ports around Duisburg-Ruhrort, at the junction of the Rhine and Ruhr, handled about 40 million tons of cargo, of which 1 million tons were coal, while Mannheim-Ludwigshafen handled 12 million tons.[3] Upstream most of the traffic is by barges of 800- to 2000-ton capacity. Strasbourg had a heavier traffic than the sea-borne trade of Rouen or Marseilles. The downstream movement of coal, fertilizer, chemicals, and steel and the inbound movement of iron ore, grain, and petroleum gives Rotterdam, the major Rhine mouth port, a heavier transit trade than any other seaport in the world. The Rhine drains one of the world's most productive areas, and on no other river are large cities and towns so numerous (see Fig. 603).

Other rivers serve the North European plain. Among these the Elbe ranks second only to the Rhine in commercial importance. The Elbe is not so deep as the Rhine, and its flow is less uniform, but it affords a splendid water route from Prague through Dresden and Magdeburg to Hamburg, Germany's leading seaport. Large quantities of sugar, potash, and coal move downstream, while imported grain is carried upstream. To the east, the Oder connects the mineral-industrial area of Upper Silesia with the North Sea at Stettin, while to the west, the Weser serves Bremen, Germany's second port, and even the winding

[3] Jean Gottman, *The Geography of Europe*, rev. ed., Henry Holt & Co., New York, 1954, p. 398. See also Edna E. Eisen, "The Structure of Rhine Traffic," *Economic Geography*, July 1934, pp. 254–267, and F. W. Morgan, "Rotterdam and Waterway Approaches to the Rhine," *Economic Geography*, January 1948, pp. 1–18.

Seine carries considerable tonnage from Rouen to Paris.

An intricate system of canals (see Fig. 603) connects these rivers with each other. In France tributaries of the Seine reach eastward and lead canals through the industrial districts of eastern France to the Rhine in the Low Countries and at Strasbourg. In Germany the Dortmund-Ems canal provides a German-controlled, Ruhr-North Sea waterway. The Midland Canal runs east-west through the heart of Germany from the Rhine to the Oder and makes Berlin a major inland port. Secondary waterways supplement this North European system and connect it with the Vistula, the Dneiper, the Danube, and the Rhone.

The Danube River. The Danube, major waterway of southeastern Europe, handles less than one sixth as much freight as the Rhine. It serves no Ruhr industrial area, has no major connections with other river systems, and flows into the Black rather than the North Sea. Above its delta are small ports for grain shipment in contrast to busy Rotterdam. Through traffic is relatively unimportant, and three fourths of the freight moves along the stretch between the narrows at Passau, on the German-Austrian border, and those at the Iron Gate in Rumania. Since 1948 the Russians have controlled shipping on the Danube, thereby reducing its importance as an international waterway.[4]

2. RAIL AND WATER ROUTES OF THE SOVIET UNION

Russian railroads. The Soviet Union is continental in size and has more people than North America. No other major power is so dependent upon rail transport. In terms of railway geography, the Soviet Union is both large and small. Her railnet of 73,160 miles, including about 10,000 miles in areas incorporated into the U. S. S. R. in 1939 and 1940, is surpassed only by the United States with its 223,779 miles of line. Yet many good-sized nations could easily occupy Russian areas that have no railroads at all (see Figs. 600 and 606). Although much shorter, the Russian railnet handles about one half the tonnage of the United States railroads, with an average length of haul about twice our own.[5] This indicates clearly the burden placed upon the Soviet rail system by fundamental geographic conditions, complicated by the rapid growth of cities and the location of new industries. Although increased regional self-sufficiency and reduction in long-haul traffic became major objectives of Soviet planning in 1938, the average haul in 1949 was slightly longer than in 1940.

European Russia has long been the most populous part of the nation, and Moscow is the logical hub of the railnet. All land west of the Volga and south of Leningrad lies within 35 miles of a railroad, maximum density occurring in the Leningrad, Moscow-Gorki, and Ukrainian industrial areas. The Ukraine remains a major surplus area, with foodstuffs, coal, raw materials, and heavy manufactured goods moving outward. Especially important are the shipments to the Moscow district, about 500 miles distant, and Leningrad, some 400 miles beyond. In order to develop forest and mineral resources of the north, rail lines were built in Czarist times from the main railnet to the ice-free port of Murmansk on the Barents Sea and to the White Sea port of Archangel. A third line, begun in the late 1930's reaches northeast almost to the Kara Sea and taps a major coal reserve in the Pechora Basin (see Fig. 298).

Eastward from the major network rail lines

---

[4] See Nicholas Spulber, "The Danube-Black Sea Canal and the Russian Control over the Danube," *Economic Geography*, July 1954, pp. 236–245.

[5] In 1940 the distribution of Russian domestic freight traffic between major carriers, measured in ton-miles was: railways, 86%; rivers, 7%; sea, 5%; and road, 2%. Comparable figures for the United States (1939) were: railways, 49%; Great Lakes and inland waterways, 12%; sea, 26%; road, 6%; and pipelines, 7%. See Holland Hunter, "Soviet Railroads since 1940," *Bulletin on Soviet Economic Development No. 4*, Birmingham (England) University, September 1950, and Harry Schwartz, *Russia's Soviet Economy*, Prentice-Hall, Inc., New York, 1950, pp. 330–358.

become appreciably thinner (see Fig. 600). The mineral-industrial area of the Urals supports a considerable network of north-south and branch lines, with major trunk lines running west and southwest. Eastward from the Urals runs the Trans-Siberian Railroad, completed in 1904, which brought settlers and manufactured goods to the rich black-earth belt reaching nearly to Baikal and carried westward this area's agricultural surplus as well as imports from the east. The rapid Soviet development of mineral production and industrial centers, especially in the Urals and the Kuznetsk Basin, but also farther east, has required a strengthening of this system. The Trans-Siberian has been double-tracked. A new "South Siberian" will provide a direct route between Kuznetsk and the southern Urals via Barnaul and Akmolinsk. A similar duplicate in the east, running north of Baikal to the Pacific near Komsomolsk has been planned. Branch lines also reach from the Trans-Siberian to new industrial and raw material centers—especially in the west, but also in the east at Komsomolsk (see Figs. 298 and 606).

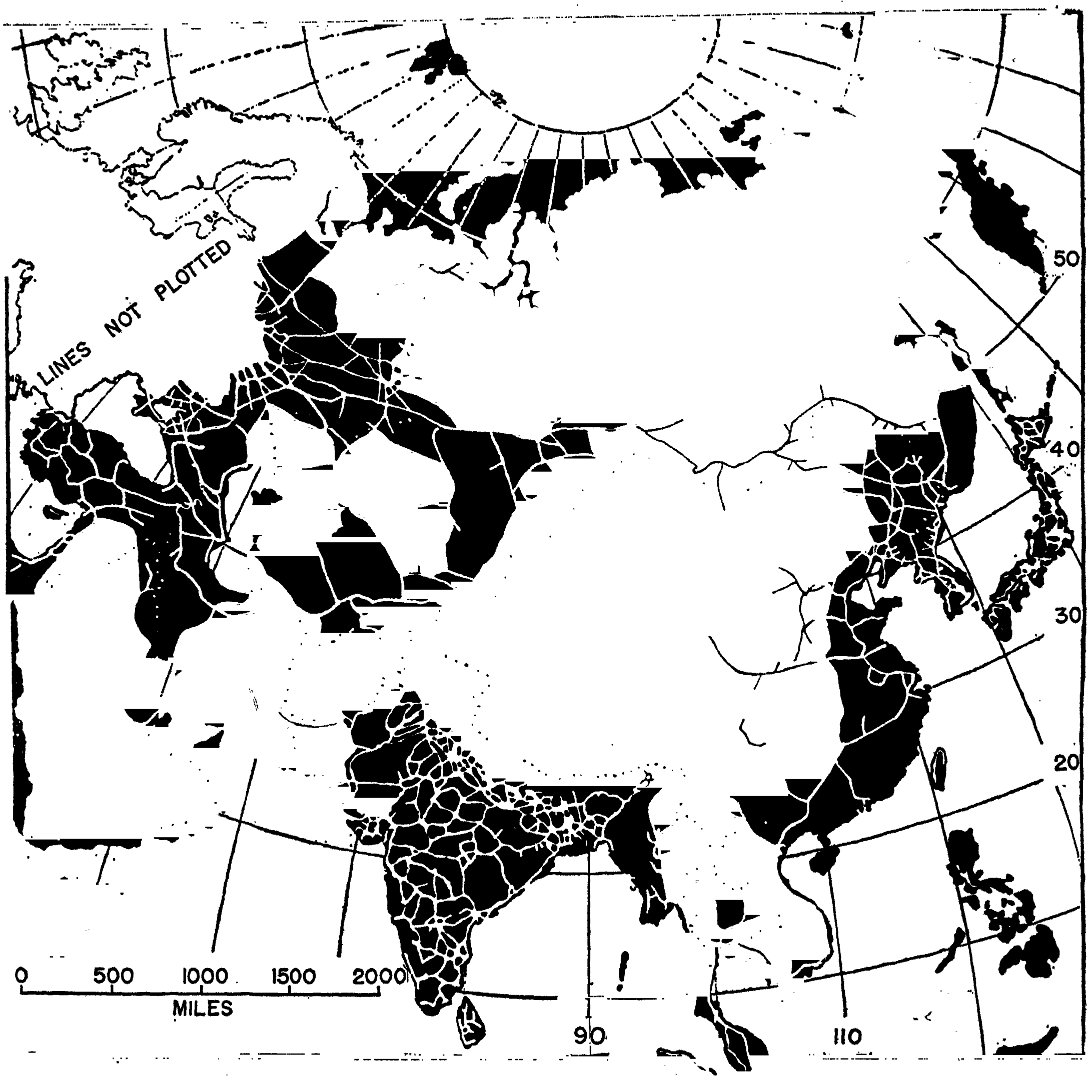
Another major project in Soviet Asia was the building of the Turk-Sib (Turkestan-Siberian) Railroad, extending from Novosibirsk through Semipalatinsk to Tashkent, where it connects with an older line that runs northwest into European Russia. Siberian grain, lumber, steel, and machinery move southward into dry Turkestan, where cotton is grown under irrigation and shipped to textile mills in both European and Asiatic Russia. The Turk-Sib and its branches run near the Chinese province of Sinkiang, which has always had close economic ties with Russian Central Asia.

Russian waterways. Despite the overburdened rail system, water routes provide only limited assistance to Russia's transport problem. Inland waterways equaled the length of rail lines in 1940, but handled only 11% as much tonnage and performed only 9% as much ton-mile service. River transport is highly seasonal, virtually ceasing during the four winter months (longer in the north). In addition several major traffic areas are poorly served by river transport. For example, there in no direct waterway connection between the Ukraine and Moscow, and the southern rivers west of the Volga handle only 10% of Russia's waterway traffic. Another 10% moves on the rivers of Soviet Asia, which flow north to the Arctic and therefore are small aid to the major east-west exchange in Siberia or the traffic with Russian Turkestan. About a third of the traffic moves along the waterways of northern and northwestern European Russia, mostly downstream shipments of timber.

The 2300-mile Volga carries about half of the water-borne tonnage and is Russia's closest counterpart to the Rhine or the American Great Lakes, although it serves no major coal-steel agglomeration and flows into the land-locked Caspian Sea. From its headwaters northwest of Moscow, the Volga flows eastward through a forested area to be joined by the navigable Kama, which drains the western slopes of the Urals. Here it turns south to flow through a major grain area and, lower down, a pastoral region. Upstream traffic—chiefly petroleum from the fields around the Caspian, fish, and grain—considerably exceeds downstream movement—principally timber and lumber. Canals connect the Volga with Moscow and, from Rybinsk reservoir (38° N. Lat.), with Leningrad and the Baltic-White Sea waterway. The recently completed Volga-Don Canal connects the lower Volga with tidewater and provides a through, although lengthy, waterway between Moscow and the eastern Ukraine.

Despite these interconnections, the average length of haul on waterways is shorter than on the railroads. This reflects the importance of lumber and building materials (two thirds of total water-borne tonnage) moving over comparatively short distances from forest to farm land and is another indication of the limited contribution of waterways to the heavy traffic between and within the major productive regions.

The role of coastal shipments, so important



Asia is big—and inaccessible. Four times as big as Europe: shut off—north, tundra and ice-bound Arctic Sea; south, mountain wall, Bosporus to mouth of Amur; desert, Jerusalem to Manchurian Plain. Ships sail almost to center of Europe. They cannot easily skirt all the coasts of Asia. Look at the rainfall map on front endpaper. Ponder the areas without rails. ***Based on copyrighted map by Mark Jefferson***

in Europe and the United States, is minimized by the long sea distances between Russia's short stretches of ice-free coast. The notable Russian accomplishments in transport along the Arctic coast are more significant for timber trade and the economic development of these coastal areas than to the solution of existing transport problems.

3. LAND AND WATER ROUTES OF ASIA

Natural obstacles to Asiatic commerce. Asia is old. Asia is in an infancy in which the old peoples, gripping the new tools and mechanisms devised in the West, are starting forward to the rebuilding of their old continent and to the rediscovery of world power. She is the seat of ancient civilization and of the oldest extensive commerce, yet that commerce has always been handicapped by environmental hindrances that will tend to impede her new trade as well.

The continent of Asia is five times as large as the United States. Its mere size divides its different parts by enormous distances. The

conformation of the land has presented other barriers more prohibitive than distance. There are no large inland seas reaching deep into the land mass as in Europe. There are no rivers flowing from the arid Asiatic heartland, and much trade must depend upon land transportation. Deserts and mountains create almost insuperable difficulties and have limited the commerce of such areas to small proportions.

The heavy commerce of Asia, like her dense population, has been dependent upon the great rivers and river plains of the south and east, and here only has there been trade in the food supplies and the heavier articles that are typical of present-day commerce. Extensive railnets have been developed in Japan and India, and in Siberia the Russians have made remarkable progress in building railroads. Large portions of Asia may be said to lie undeveloped, awaiting modern means of transportation.

The old caravan routes. Until the coming of the railroad, overland commerce in Asia was dependent upon the caravan. Even today, beyond the railroad and navigable waterway, many caravan routes extend into the vast interior of Asia. For thousands of years the caravan has contended against the obstacles of nature, using horses, mules, donkeys, oxen, yaks, and men as pack animals in the mountains, camels in the deserts, and carts and sledges on the flat plains.

The caravans from China to the west and northwest have been chiefly the caravans of the desert, following the routes of the desert, which comes down to within a hundred miles of Peiping, reaches northward nearly to Lake Baikal, southwestward to Tibet, and westward to the Caspian Sea. Across this waste China has for ages had a caravan trade, and the camel has been a familiar sight on the streets of Peiping since before the birth of any European nation.

The most important Chinese caravan route is that with and through Siberia, the routes from Peiping and Hankow combining and reaching Lake Baikal by way of the desert station of Urga. Another route passes up the Hwang Valley and across Chinese Turkestan into Russian Turkestan. At Hami, 94° W. Long., the route branches, the southern arm crossing the high ranges via Kashgar and the northern one going to Tashkent via Kuldscha. A third route of lesser importance connects Chengtu, capital of the rich province of Szechwan on the upper Yangtze, with Lhasa in remote Tibet. A fourth route connects Kunming (Yunnanfu), a mining city of the plateau of Yunnan, with the Burmese town of Bhamo on the Irrawaddy River. A part of this route was the site of the famous Burma Road during World War II.

The caravan routes that center in Turkestan were, prior to the advent of Russian railroads, continued to Europe by a direct route from Tashkent to Orenburg at the end of the Urals, and by a more southern route via the Caspian and Black Seas to Istanbul (Constantinople) and southern Russia.

Commerce that must traverse such enormous distances on pack animals over mountain, desert, swamp, dune, grassy plain, and frozen waste has pressing limitations of high freight rates that exclude anything but goods of the highest value—luxury goods, metal work, silks, cloth, fine leather, rugs, spices, and tea. The day of the transcontinental caravan is almost over. At best it is a poor and weak rival of the poorest railroad. When the modern highway appears, the beast of burden gives way to the motor truck. When faced with such competition, the caravan station becomes the embodiment of hard times and decay, and the caravan route is reduced to the status of a feeder and distributor of the newly mechanized trade route.

The Japanese railnet. Japan is rugged, compact, insular, and very densely populated. Railway construction has been difficult and costly. Steep gradients, curves, tunnels, and bridges are common, and narrow-gauged tracks are necessary. Level land is at a premium, land values are high, and railroad rights-of-way are expensive. Nevertheless, Japan has developed a denser railnet than any other country of Asia. Maximum density occurs on the small and crowded plains of eastern Honshu, the largest island and the

site of Japan's greatest urban, industrial, and commercial development.

No point on Honshu lies more than 100 miles from the sea. Japan's 17,000-mile coastline has hundreds of good harbors of great use to the merchant marine. Large quantities of heavy and bulky commodities are carried by coastwise vessels, while manufactures and other goods of high value move by rail. Regular train service is maintained between three of the main islands. On the south Honshu is linked with Kyushu by a submarine railway tunnel under the Strait of Shimonoseki. On the north train ferries shuttle across Tsugaru Strait between Honshu and Hokkaido.

Japanese railroads regularly derive more revenue from passengers than from freight. In 1951 the railroads of Japan carried 5732 million passengers, as compared with 1001 millions in the United Kingdom and 484 millions in the United States. In Japan low rates stimulate railway traffic.

The railnet of India and Pakistan. Early railway construction on the Indian subcontinent naturally radiated from the great seaports of Calcutta and Bombay, and on a smaller scale from Madras and Karachi. Today India and Pakistan are spanned by 40,900 miles of line, and their extensive railnet stands in contrast with the paucity of railroads on the rest of the Asiatic mainland (see Fig. 606).

The network of steel rails is thickest in the populous and productive Ganges Valley, while minimum density occurs in such sparsely populated areas as dry Baluchistan, the Thar Desert, and the rugged eastern Deccan. The Western Ghats fringe the sea so closely that no coastal railroad has been built south of Bombay. On the north the lofty Himalayas terminate railway construction, although various lines climb the lower slopes to the tea plantations in the east and to such health resorts as Darjeeling and Simla.

Railway rates are low, and agricultural products yield most of the freight revenue. About one third of the total railway revenue is derived from passenger traffic. There is something magic about mobility, and millions of poor natives love to ride on the British-built railroads even though they are packed into third-class coaches and on flat cars with no more elbow-room than the canned sardine. As Mark Jefferson observed, there is no people so backward that it does not want to "go."[6]

The railroads of China and other Asiatic lands. An incipient railnet serves the eastern part of China between the Great Wall and the Yangtze-Kiang. Railway lines radiate from the capital city of Peiping to the nearby port of Tientsin, northeastward into Manchuria, westward into Suiyan, southeastward to the cities of Nanking and Shanghai, and southward through Hankow to Canton. A few tentacles extend inland from the sea. The vast area of China proper has only 13,000 miles of line, as compared with 5400 miles in Manchuria and 2500 miles in Formosa.

Inland waterways and coastwise shipping carry far more freight than the Chinese railroads. Beyond the railroad and the waterway, freight continues to move on the backs of pack animals, in man-propelled wheelbarrows and carts, and on the backs of human porters. Most of China's teeming millions continue to travel by jinrikisha and sedan chair, sometimes on the backs of animals, but most frequently on foot. Man measures distances in terms of time rather than in terms of space. Motor vehicles are rare (see Table 26:1).

With few exceptions, railway development in the remainder of Asia is distinctly of a tentacular type. Here the prime function of the railroad is to connect productive inland localities with nature's greatest highway, the open sea. Tremendous areas of the Asiatic continent have no railroads at all (see Fig. 606 and Table 34:2).

The importance of Asiatic rivers. Beyond the reach of the railroad, in most of Asia the worst of rivers is better than any means of transportation by land. For many centuries Chinese junks, rafts, inflated oxhides, and other craft have sailed or floated upon streams

[6] Mark Jefferson, "The Civilizing Rails," *Economic Geography,* July 1928, p. 219.

that would be utterly neglected in the Occident. China has about 100,000 miles of rivers and canals, and a large portion of this mileage is used for navigation in one way or another.[7] Greatest of Asiatic inland waterways is the 3100-mile long Yangtze-Kiang, which empties into the East China Sea just below Shanghai, China's largest city and leading seaport.

Three reasons account for the commercial importance of the Yangtze-Kiang. (1) It has navigable branches flowing into it from north and south, and a far-reaching system of canals that open up great tracts of territory. (2) There are tremendous populations dependent upon these waterways. (3) There is virtually no railway competition, as railroads parallel only a small part of the lower course of the river. Yangtze traffic includes large quantities of foodstuffs destined for urban markets. Silk, tea, tung oil, coal, and other commodities move down the river, while cotton goods, kerosene, and other manufactures are major items of freight that are carried upstream.

Ocean vessels traverse the Yangtze at all times of the year between Shanghai and Nanking. In the high-water season of summer, ocean vessels of 10,000 tons ascend the river to Hankow, but navigation in winter is restricted to boats of less than 10-foot draft. Shallow-draft steamers maintain year-round service as far as Chungking, 1500 miles from the sea. For nearly 400 miles above Ichang the river is made perilous by boulders, frequent rapids, and a strong current. While steamers and motorboats can navigate this section of the river, other craft must be pulled upstream through the rapids by long ropes in the hands of sweating coolies.

In south China the Si-Kiang and its canals perform the same function as the Yangtze, but for a smaller area, having as outlets the great ports of Canton and Hong Kong. In north China the Hwang-Ho is navigable only for short distances because of the huge quantities of loose mud that it carries. The metropolis of the Hwang Valley is Tientsin, the port of Peiping. In northern Manchuria the Amur-Sungari is navigable by steamers as far as Harbin, while in southern Manchuria the Liao is useful for shipping between Newchang and Mukden.

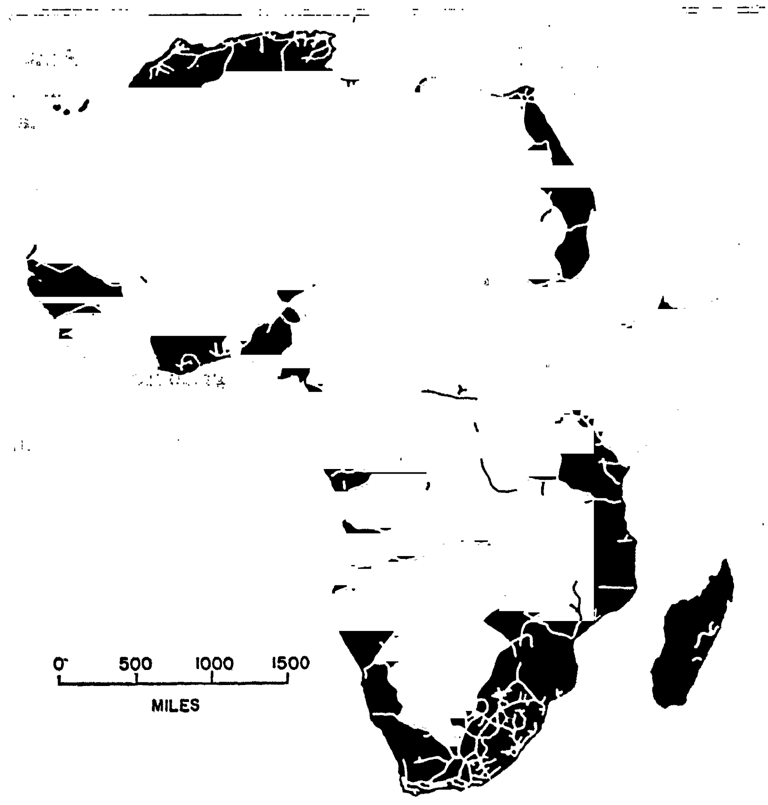
In Indochina, Thailand, and Burma the settlements of trading peoples are all on or near the navigable rivers. Rangoon at the mouth of the Irrawaddy, Bangkok near the mouth of the Menam, and Saigon on the delta of the Mekong became the great rice-exporting ports of the world, and they also export much teak timber that has been floated downstream. On the subcontinent of India the seats of ancient empire and trade were the rich valleys along the navigable courses of the Ganges, Brahmaputra, and Indus. Here are many historic names. In present-day India and Pakistan, however, the railroads have taken over practically all the river trade.

4. THE RAILROADS, RIVERS, AND LAKES OF AFRICA

The commercial development of the dark continent. Although Africa had been circumnavigated before the discovery of America, the sinister title of "Dark Continent" has stood into this very decade for the mysterious continent, filled with the hidden dangers of the venomous unknown. African commerce has been thought of in terms of beads and savage barter, but now no continent is changing more rapidly. Its present commerce is relatively small, but a far more active future is promised as a result of new transportation routes that have been opened in many directions.

African railroads and steamboat lines have been developed much faster than commerce actually warrants, because colonial governments and the colonizing powers of Europe are building lines into the wilderness to subdue territory in the hope that commerce will come later. Trade trails are being cut through the thickest jungles. Immense areas have been given some accessibility to the outside world. The frontiers are being pushed back.

[7] See George B. Cressey, *China's Geographic Foundations*, McGraw-Hill Book Co., New York, 1934, pp. 43–48.



Land more than 10 miles from railway is black. Do not forget the navigable Niger and the mighty Congo with its navigable branches. Isolated central African lines are Congo system feeders or connections around falls. Look at the rainfall map on front endpaper. *Based on copyrighted map by Mark Jefferson*

Nature places obstacles in the way of white traders and settlers. Africa's regular coastline has very few good harbors. The continent generally is a plateau with abrupt descents to the sea. In Europe, Asia, and the Americas the great rivers offer easy navigation far into the interior. In Africa they come tumbling down to the sea and are often blocked by rapids and falls. In tropic sections the coasts are usually low, swampy, and malarial, almost prohibiting land transit to the interior and giving the newcomer a most unfavorable idea of the entire continent. Only at the extreme ends of the continent are there coasts where white men can live in comfort.

African railway development. Among all continents, Africa has least access to the railroad (see Fig. 610). Nowhere in Africa is there even the beginning of a dense railweb comparable to the one that now serves the productive Argentine pampa. In its northern and southern extremities the continent is drier, more temperate, and more progressive, and here railway facilities are best. In the humid, middle part of Africa, the railroad is often auxiliary to the river and the lake, and beyond the reach of the railroad and steamboat the caravan of native porters is still used for the carriage of freight. All routes lead down to the sea.

The Union of South Africa is quite well served with an extensive railnet, and it leads the continent in number of motor vehicles (see Fig. 610 and Tables 26:1 and 34:3). Small railnets have been developed in Morocco, Algeria, Tunisia, and Egypt. Throughout North Africa the picturesque camel caravan has lost much of its trade to the railroad and the ubiquitous motor truck. Indeed, not even the burning sands of Sahara can halt the rugged four-wheeled wonders from Detroit. In South Africa the ox-cart caravans that once carried men and goods from the Zambesi to the Cape are now relics of the past. Most of Africa is a colonial appendage of Europe, and the rôle of Britain's empire builders is shown

by the fact that two thirds of the continent's railway milage is concentrated in the Union of South Africa and British colonies and mandates.

The flow of African railway freight is distinctly centrifugal. Local traffic is small, and the outflow of minerals, crops, and pastoral and forest products far exceeds the volume of inbound manufactures from foreign lands. The prime function of African railroads is shown by the outbound shipments of phosphate from French North Africa, cotton from Uganda, Nigeria, and the Anglo-Egyptian Sudan, coal from Natal, palm oil and cacao from West Africa, and copper and other minerals from Northern Rhodesia and the Belgian Congo.

TABLE 34:3. The Population and Railroads of Africa and Australasia, 1952

Country	Population (millions)	Total miles of line[a]	Miles of line per 100 square miles
Africa			
Algeria	9.1	2,786	.3
Anglo-Egyptian Sudan	8.8	2,013	.2
Angola	4.2	1,442	.3
Belgian Congo	11.8	2,919	.3
Egypt	21.4	4,023	1.0
Eritrea	1.0	233	1.8
Ethiopia	15.0	487	.1
French West Africa	17.4	2,705	.2
Gold Coast	4.0	365	.5
Kenya and Uganda	11.1	1,625	.5
Liberia	2.7	0	.0
Libya	1.2	242	.04
Madagascar	4.4	534	.2
Morocco, French	8.1	1,063	.6
Mozambique	5.8	1,180	.4
Nigeria	29.6	2,208	.7
Rhodesia	4.2	2,711	.6
Sierra Leone	2.0	227	.8
Southwest Africa	.4	1,552	.5
Tanganyika	7.8	1,300	.4
Tunisia	3.6	1,273	2.6
Union of South Africa	12.9	13,280	2.8
Australasia			
Australia	8.6	28,019	.9
New Zealand	2.0	3,532	3.4

a Route mileage available for public service, excluding multiple track, yard track, and sidings.
Source: Population data from U. N., *Statistical Yearbook 1953,* and *The World Almanac and Book of Facts for 1954.* Total railway mileage data from the Association of American Railroads and *The Statesman's Year-Book, 1953.*

African rivers and lakes. Most of central Africa from about 17°N. Lat. to about 17°S. Lat. remains dependent upon rivers and lakes for much of its transportation. Long rail-and-water routes lead from the continental interior to various seaports. As yet only the rich copper mines of the Belgian Congo and Northern Rhodesia and the tin mines and cotton fields of upper Nigeria have long and continuous rail routes to the sea. Lakes Nyasa, Tanganyika, Victoria, Rudolph, and Chad are no longer names of mystery, for these lakes, like the Congo and Niger rivers, have regular steamship service today.

The Congo River is the longest and greatest of African waterways, the river and its tributaries providing about 6800 miles of navigable water. Ocean vessels call at Matadi, 83 miles from the river's mouth, and a 250-mile portage railroad connects with Leopoldville above the numerous falls, where another portage railroad connects with the upper river, giving steamer service 2350 miles from the sea. At Kabalo the Lualaba-Congo is linked by rail with Lake Tanganyika; a line from Tanganyika to Dar-es-Salaam completes a steam route across Africa (see Fig. 391).

The circuitous Congo has lost the rich Katanga-Rhodesia traffic in copper and other minerals to shorter rail routes. The mighty river and its tributaries, however, are the main avenues of commerce for most of the Belgian Congo, which is exporting increasing amounts of palm oil, palm kernels, hardwood, cotton, copal, and coffee. Thus, modern transportation creates a different trade from that of a century and a half ago, when Negro slaves were Central Africa's chief export.

Unlike most African rivers, the Niger and its main tributary, the Benue, provide a water route from the sea to the interior that is unbroken by rapids and falls for 900 miles. Regular steamer and barge service is maintained on the lower river for about 500 miles. The river has lost much of its traffic to the railroads, which carry tin, cotton, palm kernels and palm oil, peanuts, and hides and skins from the interior directly to Port Harcourt at

the mouth of the river and to the port of Lagos on the Bight of Benin.[8]

In its middle and upper course the Niger flows through the French Sudan. Hides and skins, peanuts, and other products are shipped upstream to Bamako and thence by rail to the Senagalese port of Dakar. Alas for the myths of geography, Timbuktu, with its jingling rhymes typical of remoteness, has become a commercial reality of steam and rail and telegraph, not to mention the radio and airplane. Today the safe steam route to the sea has cut sadly into the traffic of the camel caravans that for ages wended their weary way from one oasis full of robbers to another on the long journey to the Mediterranean coast. Camel, truck, train, and plane now meet at Kano, Nigeria.

In spite of its cataracts, the Nile River for centuries was the main thoroughfare connecting the Mediterranean world with equatorial Africa. In modern times the river has lost most of its freight traffic to the railroad that parallels its lower course and that carries phosphate, rice, onions, and sugar to Alexandria for export. Between the First and Second Cataracts there is no railroad, and here the river competes only with the motor truck and the camel caravan. Above the Second Cataract railroads in the Anglo-Egyptian Sudan extend southward to Sennar on the Blue Nile and Kosti on the White Nile, and they carry large shipments of short-staple cotton for export through Port Sudan on the Red Sea. Today the majestic Nile stands unique among the world's great rivers in that more than 80% of its traffic is passenger trade.[9] Most passengers are opulent American and European tourists gaping at the pyramids and desert scenery from the decks of luxurious steamers operated by the well-known firm of Thomas Cook & Sons.

5. RAILWAY DEVELOPMENT IN AUSTRALASIA

The railroads of Australia. Aridity is Australia's big handicap. Approximately one third of the nation is a desert, and another third is too dry for crops (see front endpaper). Only 13% of the land area is fair farming land with over 20 inches of rainfall.[10] Although Australia and the United States are almost identical in size, the Australian population is only a little larger than that of New York City. About nine tenths of all Australians live along the southeastern seaboard between Brisbane and Adelaide, a land that is mostly temperate and moist. A minor concentration of population is found in the southwest around Perth, where Mediterranean climate prevails. No town or city of any importance lies farther than 50 miles from the sea.

It is not surprising that railway construction in Australia was considered too speculative for private enterprise. Each of the Australian states built its own railroads. Many lines were built with little regard to traffic potentialities, and a variety of gauges were used, an obstacle that now retards through traffic between the most populous states.[11] In 1917 the Commonwealth government filled in the missing link in the east-west transcontinental railroad by building a 1050-mile line from Port Augusta to Kalgoorlie, a railroad that follows the 10-inch rainfall line almost all of the way. Australian railroads as a whole seldom earn the interest on their investment.

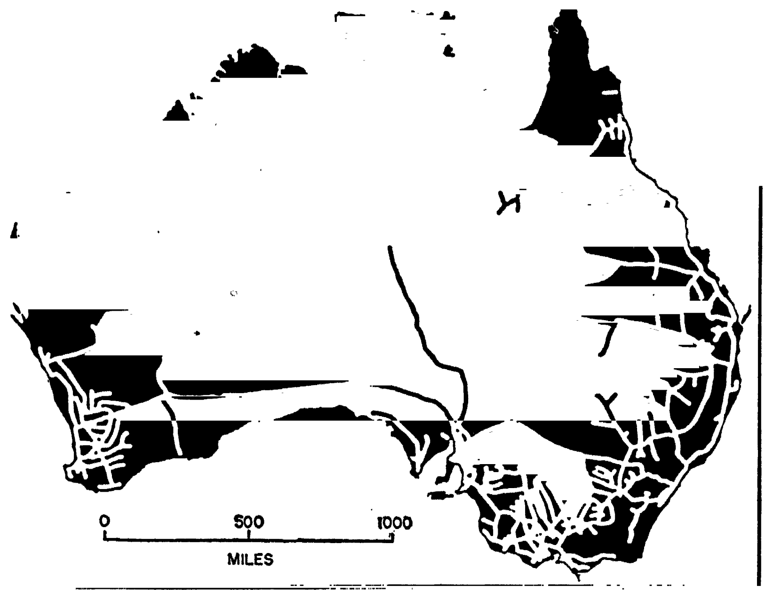
While most of Australia's 8½ million people have easy access to the railroad, most of the nation's land does not (see Fig. 613). Southeastern Australia and its two big cities of Sydney and Melbourne are served by a well-developed railnet, which is linked by a little-used railroad with a small railnet in the

[8] The Niger Delta, 14,000 square miles in extent, is covered by a dense mangrove swamp. Because of the heavy shipments of palm kernels and palm oil, the navigable distributaries are known to seamen as the "Oil Rivers."

[9] Alfred C. Hardy, *World Shipping*, Penguin Books, Ltd., London, 1943, pp. 122–123.

[10] For an analysis of potential land use, see Griffith Taylor, *Australia*, E. P. Dutton & Co., Inc., New York, 1940, pp. 434, 444.

[11] A gauge of 3 feet 6 inches is used in Queensland, Northern Territory, Western Australia, and Tasmania. In New South Wales it is 4 feet 8½ inches, and in Victoria, 5 feet 3 inches. South Australia has all three of these gauges.



Railways in 20-mile band. Look at rainfall map on front endpaper to explain railway location. ***Based on map in The Railway Gazette, Overseas Railways Edition, London, December 1953; after Mark Jefferson***

southwest. No through line spans the country north and south. Numerous railway tentacles extend into the dry interior, while one runs along the tropic northeast coast to Cairns, about 600 miles south of Cape York. Since most interstate commerce is handled by coastwise shipping, the main function of Australian railroads is the carriage of wheat, pastoral products, and a few minerals to coastal cities for local consumption or for export.

Transportation in New Zealand. In contrast with Australia, the two main islands of New Zealand have no desert, no semiarid land, and no droughts. Mild winters, mild summers, and abundant rainfall make New Zealand a land par excellence for the sheep and the dairy cow. Four fifths of all improved land is now in pasture. New Zealand's great exports of mutton, wool, butter, and cheese have a short rail haul to the seaports of Auckland, Wellington, Christchurch, and Dunedin before traveling halfway around the world to the big markets of Europe and the United States.

North Island and South Island are connected by regular steamer service. On both islands many rivers come tumbling down to the sea, but these are used for water power rather than for navigation. New Zealand is served by 2500 miles of railroads, maximum density occurring on the Canterbury Plain along the east coast of South Island. Both New Zealanders and Australians are building more and better highways, and they have become close rivals of Americans and Canadians in the use of the automobile (see Table 26:1).

35· The Ocean and Its Carriers

1. THE WORLD HIGHWAY

Access to the sea. To understand world commerce we must first know the part played by the ocean. The nation that does not touch the ocean is like a house that is not upon the street, and some of the bitterest strifes of history have been for the possession of bits of coast. Once a nation has reached the sea it has possessed itself of a part of the world highway that reaches everywhere and belongs to each and all who own even a tiny strip.

The relative cheapness of ocean transportation is largely the result of three conditions. (1) Nature provides the ocean shipping company with a free highway—no original cost, no upkeep, and no taxes. In contrast, U. S. railroads in 1953 had a capital investment of $158,107 per mile of line.[1] (2) Water is buoyant. It bears the weight of the ship and its cargo, and only motive power is needed, while on land additional power must be used to overcome friction. The importance of friction is shown by the fact that a horse can haul 1 ton of freight in a two-wheeled cart on a level road but can pull 40 tons in a canal barge. (3) The ocean shipping business is one of the world's most competitive industries, and low rates resulting from competition benefit shippers and consumers everywhere.[2]

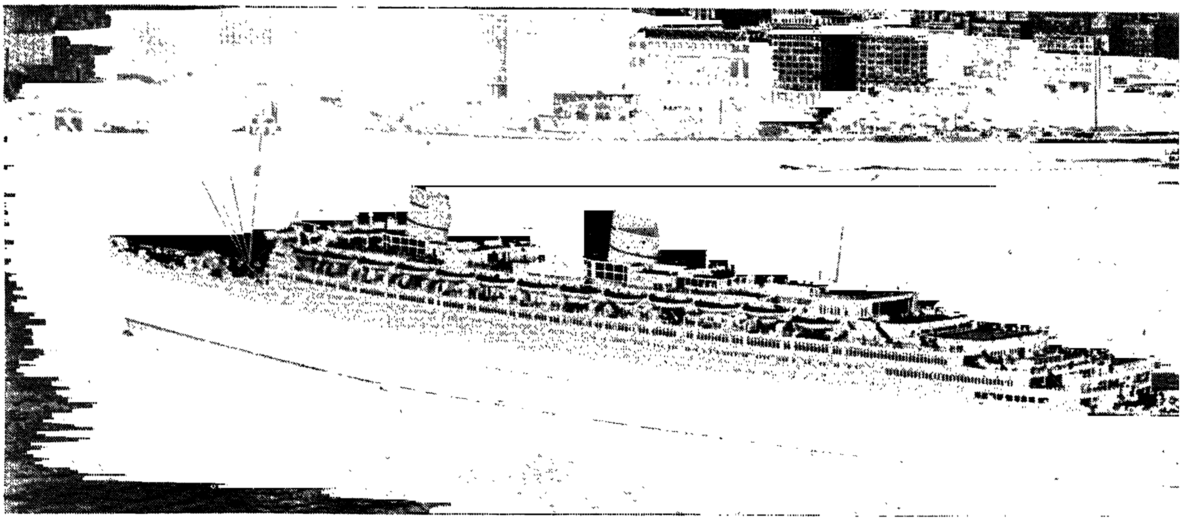
2. TRAMP AND LINER SHIPPING

Two main types of ocean service. For more than 100 years tramp and liner shipping have been the two main branches of the ocean shipping industry.[3] The principal feature that distinguishes the liner from the tramp is regularity of service. A liner is any vessel that operates over a fixed route on a regular schedule of sailings. Since a schedule of regular sailings can be maintained only with a number of vessels, the number depending upon the length of the route and the frequency of sailings, it follows that liners belong to a fleet or "line," and thus the liner derives its name.

[1] This figure includes not only the investment in roadway and tracks but also stations, engine houses, shops, signals, and other physical equipment. However, the ship's terminal is not *free*. Even in public ports there are charges.

[2] Other factors, of course, contribute to the relative cheapness of ocean transportation. The freight-carrying capacity of a railway train is broken up into many small units or cars, involving waste in the form of deadweight or tare, while the almost unobstructed hold of a cargo vessel has very little loss from deadweight. The cost of building an ocean-going cargo vessel and the amount of labor needed to operate it are much less than the cost of building and operating the equivalent in locomotives and freight cars. The average freight haul on the ocean is much longer than on the land, with the result that the ocean carrier has lower cargo-handling expenses per ton-mile.

[3] See C. Ernest Fayle, *A Short History of the World's Shipping Industry,* George Allen & Unwin, Ltd., London, 1933, pp. 253–270; J. Russell Smith, *The Ocean Carrier,* G. P. Putnam's Sons, New York, 1908, pp. 26–53; *Report of United States Maritime Commission on Tramp Shipping Service,* House Doc. 520, 75th Cong., 3d Sess., Washington, 1938; and Alfred C. Hardy, *The Book of the Ship,* Samson Low, Marston & Co., Ltd., London, 1950, pp. 165–174, 205–213.



British queen, speed queen of the seas—*Queen Elizabeth,* 1031 feet long, 1280 crew, 2233 passengers—until we subsidized the present champion, the S. S. *United States,* which cost $70 million with Uncle Sam contributing $42 million—a defense item. Take a good look. Small chance of another being built. Too much luxury traffic now goes by air. *British Information Services*

On the other hand, a tramp is any vessel that has no fixed route and no regular time of sailing and which is ever seeking those ports where profitable cargo is to be obtained. The tramp is a free lance that has earned its name from its gypsylike existence, for it will carry cargo to almost any destination, and in the course of its wanderings the tramp may traverse every sea and circumnavigate the globe many times. In contrast with the liner, the tramp ship is a jack-of-all-trades.

Many liners carry passengers, express, and mail. Manufactured goods have long been a major cargo. The liner caters to cargoes requiring faster and more regular service than that afforded by the tramp, which seldom has a speed exceeding 10 knots.[4] The great majority of tramp cargoes are commodities (1) of sufficiently low value that cheapness in transport outweighs any value of speed or regularity in delivery, (2) of relatively large bulk or heavy weight, (3) that do not require exceptional facilities on the part of the carrier for preserving or handling them, and (4) that are available for shipment in full cargo lots. Grain, coal, sugar, cotton, lumber, and various ores are among the cargoes that are commonly carried by tramps.

A shipper who has enough cargo to fill a vessel may charter a tramp, just as one charters a truck or moving van that is available for private hire. It is an individual matter entirely between the shipper and the shipowner. The business is not heralded by expensive advertising, fine engraving, and handsome cuts distributed throughout the six continents. All this publicity is costly. The tramp is on the list of some shipbroker or brokers who secure a freight for her on commission, and she goes about her work unnoticed by the traveling public or by the headlines of the newspapers. She is reported only in the maritime columns of the business journals, and she is watched only by those whose business it is to know about her travels, but she carries much of the world's freight.

Unlike the liner, the tramp operates as a single unit of transport and does not conduct its operation in concert with other vessels. The tramp is free to fluctuate from one route to another in response to the shifting requirements of trade, while the liner is restricted to its route almost as rigidly as the railway train is confined to its track. The tramp is free to lie in port when work does not offer, thereby saving fuel, wages, and other expenses. The

[4] A knot is a nautical mile (6080 feet.) per hour.

liner must maintain a schedule and make sailings to ports of call, which in themselves are often unprofitable but which are necessary, since a line vessel must maintain a reputation to establish relations with shippers and form a clientele. The tramp usually carries a cargo of a single shipper, and it is free to choose the most profitable cargo that is available at a given time. The liner carries the goods of many different shippers; it does not discriminate among them; and it stands ready to accept the goods of all shippers, provided that space is available and that shippers are willing to comply with the terms of freight.

It is clear, therefore, that the tramp enjoys much greater flexibility in operation and management. The advantages of flexibility in management, a large carrying capacity due to the boxlike construction of the ship (see Fig. 617), and a great saving in fuel because of slow speed enable the tramp to charge the world's lowest freight rates for the transportation of many low-valued, bulky, and heavy commodities. Tramp service is distinguished by its cheapness and flexibility; liner service, by regularity and greater speed.

The charter of tramp vessels. The freedom of the sea makes competition easy, but it is especially easy among the tramp vessels. When a great line is established, full competition can only take the form of another great line, which involves much capital and careful organization. Competition in the tramp service requires merely another ship. It does not even require that the owner shall be a successful manager. He may rent his vessel out to another who has the necessary acquaintance with the trade, or he may secure a manager who will receive a salary or commission. Any person who has $1 million can go to any one of the scores of shipbuilders and have a tramp steamer built in a few months.[5] He can have a ship built on partly borrowed money, the builder taking a lien on the ship; and when she goes to sea she will go mortgaged. Or, if the newcomer should desire to engage in the ship business and does not care to wait for the ship to be built, there are numerous shipbrokers who will sell him an old one within an hour. The owner of this single ship is then in a position to compete in the world's freight market, and can take service on any sea, in any country, and from hundreds of ports.

The ocean is a world ocean; the ship market is a world market; the charter traffic is a world traffic; and the ocean rate a world rate. Wherever freight offers, there the ships may go and do go.[6]

The tramp traffic. This tramp ship—which may be built and owned by anybody, and which may sail in all seas and carry the products of any or all countries—is a remarkably free agent. It is to be had, however, only by those persons who can afford to load a whole ship; and that is about the only limitation upon the character of produce that is carried by the tramp vessels. Nearly one third of all tramp business consists of the carriage of grain, the remainder consisting of a wide variety of cheap and bulky commodities. Only occasionally some manufacturer ships enough heavy goods, such as steel rails, locomotives, and agricultural machinery, to fill a vessel, in which case he may charter a tramp.

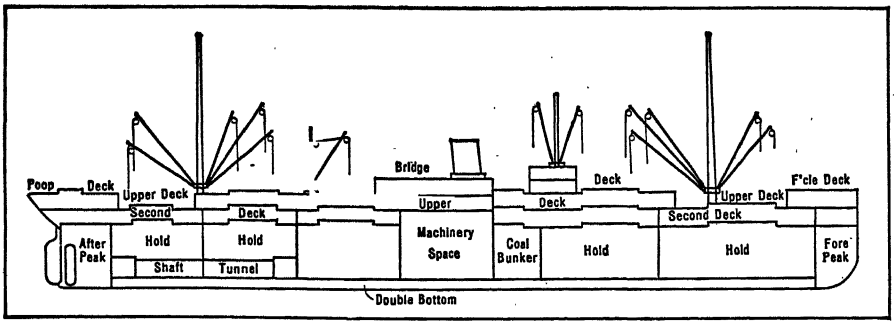
The regions producing the tramp freight and the regions consuming the same are widely scattered and embrace every important country in the world. For example, grain is

---

[5] On June 30, 1951, the cost of building a tramp steamer of 9500 deadweight tons was £450,000, and the cost of a tramp motorship of the same size was £480,000. "Fluctuations in Shipping Values," *Fairplay,* July 5, 1951, p. 48.

[6] "Here is the *Olaf Nordsen* of Stockholm, Sweden (in New York harbor). She is about 8000 tons and a heavy broad thing, with a short funnel, and two stumpy masts rigged with derricks. She looks a seaworthy ship and probably is. The Scandinavians are a hardy race of seafarers and know good ships. We will hail the man hanging over the stern and ask him when they left home.

"'A year ago,' he answers in broken English. 'Ve go to Vigo in Spain, den to Italy, den to Tunis. After dot ve vent to England, den come here.' She wouldn't have much speed, maybe 10 miles an hour, and it would take time to travel all the distances she has been. And unloading cargo is a slow business in Spanish and North African ports." [This is still true.]—*The New York Times,* June 1924.



Longitudinal section, World War I tramp, 429 feet long, 4000 indicated h.p., hold capacity of 461,923 cu. ft., 11,548 tons. Like the ore boats (Fig. 589), she resembles a floating box with tight top. ***Sir Abell Westcott***

shipped from our Gulf and Atlantic ports, from Argentina, from Australia, from the Black Sea ports, and from Canada, both east and west coasts. A further analysis of the origin and destinations of prevailing charter commodities would show that we truly have a world problem. There are hundreds of ports with freight for tramp vessels, and there are thousands of ships scattered about the world to do this work.

Management of tramp vessels. The proper bringing together of the ships and the freight is a world puzzle, compared to which the game of chess is simplicity. The ships must move around the world in such a way that the freight is all carried and that the ships that do the work have as few empty voyages as possible and keep constantly employed.

The successful adjustment of this complicated situation is a fine piece of applied geography. In its present form, it is one of the results of the development, first, of the ocean cable and, later, of the wireless telegraph. Practically every ocean-going vessel now carries a radio outfit and is seldom out of touch with the world for very long. The Baltic Exchange and Lloyd's of London (see Fig. 574), with agents and correspondents throughout the world, report every observed movement of some 14,000 seagoing vessels; maritime associations in the larger ports do the same work. Therefore, the shipowner can easily know not only where his own vessel is but where the vessels of his rivals are.

It is necessary, however, that in this work watch must be kept not only upon vessels but upon freight. Most tramp cargoes consist of products that depend upon harvest and commercial conditions. If there is to be good or bad grain harvest in Canada, Australia, or in the Argentine, tramp shipowners must know it and place their ships accordingly. The differing times of ripening of the various crops in the different producing regions and other particular seasonal demands make each port or district have its busy season and its off season. Accordingly, the manager of the tramp vessel has a number of problems to consider as he guides his ship through the maze of world commerce. The cable and radio which enable the Baltic and Lloyd's to report the movements of all vessels, also report the condition of crops in foreign countries, and enable the managers of the ships to maintain almost as good control and knowledge of their ships as does the chess player of the men on the board before him.

The manager of the tramp ship must consider more than one cargo when he makes an engagement to perform a certain voyage, for it is necessary that his ship be discharged in a place where freight for the next trip is not too far away. Otherwise, he may have a long voyage in ballast, making cost without income. The result is that the probable second voyage affects the rates for the first. The manager seeks an engagement that will release his vessel near good prospective freights, and he avoids engagements that take him into barren seas. Accordingly, this master of applied commercial geography scans the world's horizon for prospective wheat crops or other freight

supplies toward which he can work his ships with a chance of securing freight.

Tramp freight rates. It is a fact that if a vessel cannot make good earnings, it usually pays better to take low earnings rather than nothing. The consequence is that when freight is scarce the rates may go down not only to a point where there is no profit but below this, because each manager reasons to himself: "If I cannot make a profit, it is better to operate at least at cost; if cost cannot be made, it is better to operate at a moderate loss rather than to undergo a greater loss by tying up to a pier and allowing the ship to rust in idleness." The result is that ocean freight rates may go to great depths; and, conversely, they may rise to great heights, for when the freight is plentiful and the ships are scarce the only limit to which the rates may rise is set by the maximum that the shippers can afford to pay to get a particular cargo carried.

Charter rates jumped almost out of sight in the early months of World War I and World War II, and discarded old tubs of vessels were hastily overhauled and put into service, while new ones were still more hastily built. After each war freight rates declined sharply. The tramp shipping business booms in times of war, but its profits are normally meager. During the period 1922–37, the average rate of dividends paid on capital stock by British tramp shipping companies was less than 5% in every year except 1927 and 1928, and during the depression year of 1932 dividends averaged less than 1%.

Dependence of the modern world upon both tramps and liners. Tramp traffic bears a very fundamental relation to world commerce, because it carries raw materials and foodstuffs, without which the manufacturing city and the manufacturing state as at present constituted could not exist. The tramp is much like the slow freight train, while the liner resembles the fast express. The tramps handle the trade of vast quantity; the liners handle the trade of high value and the shipments of small size and great number. The liners, therefore, serve the greater number of shippers. They serve the multitude who cannot fill a ship with one consignment, and among manufacturers there must be many thousands of small shipments of finished goods to one that requires a tramp to handle it.

The manufacturing state may depend upon tramps to bring food and materials, but there is a larger dependence upon the liners that carry to market with greater speed the myriad small consignments of manufactured goods and other commodities. Conversely, a raw-material-producing country may depend largely upon tramps to take its exports and upon liners to bring its imports of valuable manufactured goods. The trade of Argentina is an interesting example. It moves as follows:

Inbound

British coal—tramp
Petroleum—tanker
Manufactures—combination passenger-cargo liner, and general cargo liner
Cement—both tramp and general cargo liner
Machinery—liner (Ford's industrial carriers carry trucks and cars southward and flax back to U. S.)

Outbound

Wheat, corn, flaxseed—tramp
Wool—liner
Meat—refrigerator vessel
Flour—liner
Quebracho extract—liner

3. THE DECLINE OF THE TRAMP

Extent and nature of the decline. At the end of the nineteenth century, the tramp held a dominant position in world trade and shipping, for it surpassed the liner in numbers, gross tonnage, potential carrying power, and the actual movement of freight. Throughout the present century the relative importance of the tramp has been steadily declining. In 1914 more than one half of the world's ocean-going merchant vessels were tramp ships, which handled more than two thirds of the world's ocean freight. In 1939 less than one third of the ships were tramps, and they hauled consider-

ably less than one half of the freight. Between 1914 and 1939 the tramp's share of the total gross tonnage of merchant shipping declined from 46% to less than 30%.[7] Furthermore, the average speed of liners has been steadily increasing, while that of the tramp has remained about 10 knots, and it is doubtful whether tramps now provide as much as one sixth of the potential carrying power available to shippers.[8]

During the present century many bulky commodities have been deserting the tramp, and a few examples may be cited to illustrate the trend. Grain has long been the tramp's major cargo, and prior to World War I a liner seldom accepted grain except when a few hours before sailing time it was found that no other cargo was available. Since 1920 many liners have engaged in the carriage of grain, and in recent years little more than half of the grain trade has remained in the hands of the tramp.[9] Iron ore, phosphate, sulfur, and cotton were once handled almost entirely by tramps, but more than one half of the overseas movement of these commodities is now handled by liners. The tramp still handles most of the world's overseas trade in coal, sugar, lumber, wood pulp, and newsprint stock, but in certain traffic areas desertions to the liner have been important.

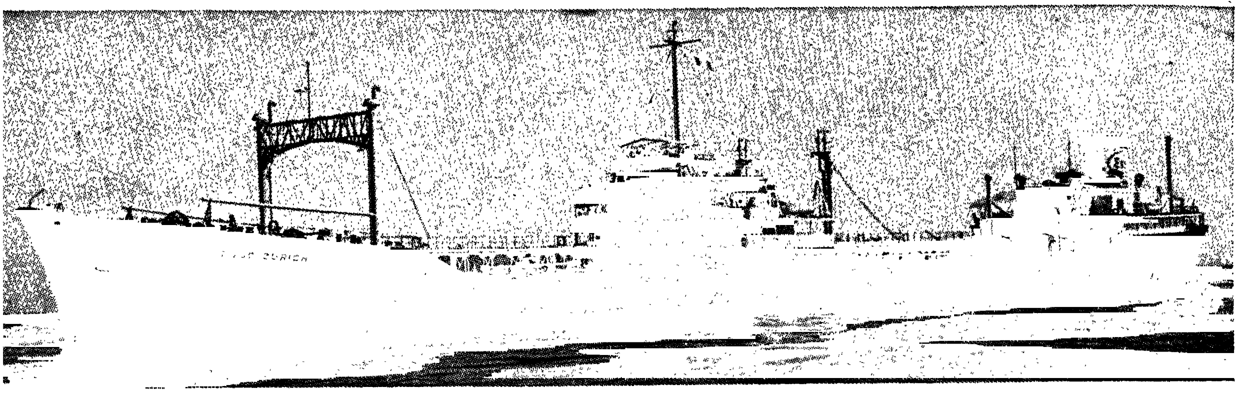
Specialization in ship construction. Like many another jack-of-all-trades, the tramp has suffered from the increasing competition of specialists. The tramp is little more than a seagoing warehouse designed for general utility, and specialization is precluded in its construction and equipment. On the other hand, the liner more and more is becoming a mechanized cargo-handling machine. The liner serves the same ports throughout the year and handles approximately the same types of products. Liner companies can forecast with reasonable accuracy the major requirements of their routes. Hence, as trade grows in volume and regularity, the liner company finds it profitable to adapt vessel construction to the cargoes carried and to the peculiarities of particular trade routes.

The degree of specialization varies all the way from the installation of a few extra gadgets for handling cargoes to the construction of new types of vessels for the carriage of a single commodity. Probably the most specialized merchant ship today is the self-unloading carrier, such as the colliers that make quick trips from Great Britain to the Continent with coal and that always return in ballast. This type of vessel cannot be employed in any other trade. Ore carriers with unusual ballasting arrangements and other special equipment handle only certain types of ore, as in the iron-ore and sulfur trades. Some refrigerator

[7] To the layman, the shipping fraternity's use of various kinds of tons is a confusing bit of nautical pedantry. Thus, a Liberty ship is rated at about 10,500 tons when it is launched, 7200 tons if it is sunk, and only 4400 tons when it enters and clears a port! A *gross ton* is 100 cubic feet, and the gross tonnage of a vessel indicates the cubic contents of the ship in terms of units of 100 cubic feet, minus certain deductions permitted by international agreement. Gross-tonnage data are commonly used in comparing the merchant marines of the world, war losses, etc.; they are used in Lloyd's *Register of Shipping;* and they are found in the official merchant-marine statistics of governments throughout the world. A *net ton* is also 100 cubic feet, and the net tonnage of a ship roughly indicates the space available for passengers and cargo. Net-tonnage data appear in port records for entrances and clearances, and they are used as a basis for tonnage taxes and dues, etc. A *measurement ton* is 40 cubic feet, this unit being used by the shipbroker in selling cargo space to shippers. A *deadweight ton* is 1 long ton or 1 metric ton, and the deadweight tonnage of a vessel indicates the cargo-carrying capacity of a freighter in terms of weight. A *displacement ton* is 1 long ton or 1 metric ton, and the displacement tonnage of a vessel equals the weight of the water that the vessel displaces. Displacement "light" indicates the weight of the vessel together with the weight of a normal crew and supplies. Displacement "loaded" is the weight of the vessel, crew, and supplies, plus the weight of bunker fuel and cargo. The difference between displacement "loaded" and displacement "light" indicates the maximum carrying capacity of the ship (weight of cargo and fuel), or its deadweight tonnage.

[8] If two ships have the same cargo-carrying capacity but different speeds, the faster ship can offer more transportation service per year. The potential carrying power of a ship is determined by multiplying its net tonnage by its average speed.

[9] The chief grain movements by tramp, in order of importance on the basis of weight, are: wheat, corn, rice, rye, barley, and oats.



Supertanker—628 feet over-all length, 82 ft. 6 in. beam, 31 ft. 4½ in. draft when fully loaded, cargo capacity when fully loaded, 226,377 barrels (42-gallon barrels), less 2% for expansion. Tankers are the latest boom in shipbuilding. Japanese yards build some for other nationals. If the three-story house amidships were longer, with staterooms, she might pass for a cargo liner, an increasing type. *Standard Oil Co. (N. J.)*

vessels specialize in the carriage of chilled beef, others in frozen mutton. Banana carriers have refrigerating and ventilating apparatus to preserve their perishable cargoes. Most tankers carry petroleum, but some are especially designed for molasses, latex, vegetable oils, whale oil, and other liquid cargoes. Many of these highly specialized vessels are operated by big corporations that own both the ship and the cargo. Others are operated by regular shipping companies that serve the general public. Virtually all of them are employed in liner service, running on schedule over established routes.

Although specialization in ship construction has led to a great diversity of ocean carriers, it is possible to divide the world's merchant vessels into eight major types. The names and distinguishing features of each of these types are presented in Table 35:1. An examination of this table reveals that there is a considerable overlapping of the characteristics of the different vessel types. For example, a general cargo liner and a tramp may be identical in their physical aspects, the only difference being that the liner is engaged in regular service.[10] The significant fact is that the eight major types of vessels meet the specific requirements of their respective trades. The shippers of the world are demanding something more than cheap transportation, and the role of the tramp ship continues to decline in many trades.

Other factors underlying the decline of tramp shipping. In addition to the increasing specialization in ship construction and equipment, two other carrier developments have enabled the liner to invade the domain of the tramp: (1) the continuous cheapening of speed and (2) the shift in fuel from coal to oil. As a general rule, tramp owners have been slow to adopt new or improved engine types. Improvements in the steam reciprocating engine, the use of the geared turbine, and the development of the oil burner and the Diesel engine have occurred predominantly within the field of liner shipping. In 1914 less than 3% of the world's merchant tonnage was driven by oil; in 1953 about 85%. The oil burner has been used chiefly by liner shipping, and many tramp owners were slow to adopt the Diesel.[11] Not only have the advantages of

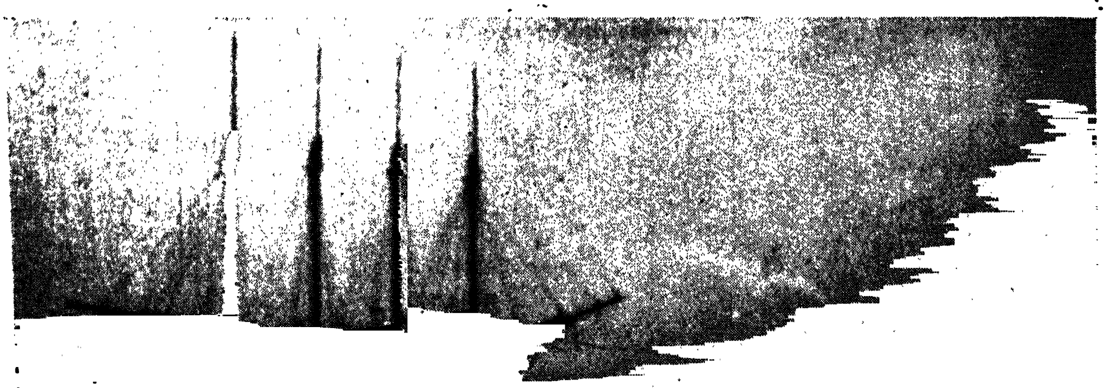
[10] It should be noted that the tramp-liner and the tramp-tanker are more nearly liners than tramps. Both tramp-liner and tramp-tanker are usually chartered on a long-time basis. Although the charterer sometimes shifts them from one route to another, they are usually operated on schedule in definite trades rather than seeking cargoes throughout the world. Nearly all Norwegian tanker tonnage is of the tramp-tanker type.

[11] The progressive Scandinavians were quick to adopt the Diesel tramp. Among the chief advantages of using oil instead of coal are: much longer voyages without refueling, lower labor costs in the engine room, greater speed in bunkering, and less bunker space needed for petroleum than its equivalent in coal.

TABLE 35:1. A Classification of Merchant Vessels[a]

Type of vessel	Service	Cargo	Equipment for cargo	Gross tonnage, approximate data	Speed in knots, approximate data
Passenger liners	Member of a fleet in regular line service	Passengers, mail, express, and small amount of high-grade freight	General	20,000 to 85,000	20 to 36
Combination passenger and cargo liners	Member of a fleet in regular line service	(a) Primarily passenger and mail (b) Half and half (c) Primarily freight	General, with occasionally tanks for liquid cargo, refrigerated holds, etc.	8,000 to 30,000	12 to 22
Specialty carriers	(a) Member of a fleet in regular line service, e.g., refrigerator ships, colliers, ore carriers, tankers, etc. (b) Independent vessels, usually on long-time charter, in quasi-regular service	Freight, usually in full cargo lots, and occasionally some passengers	Highly specialized	3,000 to 15,000	10 to 17
Industrial carriers	Member of a fleet in regular line service, controlled by company that owns the cargo, e.g., tankers, colliers, ore carriers, refrigerator ships, general cargo vessels	Freight, usually in full cargo lots, and occasionally passengers	Specialized or general	2,000 to 15,000	Under 17
General cargo liners	Member of a fleet in regular line service	Freight, usually in parcel lots, and occasionally a few passengers	General, with occasionally tanks for liquid cargo, refrigerated holds, etc.	3,000 to 15,000	10 to 18
Tramp-liners	Independent vessels, on time charter, in regular trades most of the time	Freight, chiefly bulk cargo, but often some cargo requiring specialized equipment	General, and frequently specialized equipment, such as holds for refrigerated and liquid cargoes	3,000 to 10,000	12 to 14
Tramp-tankers	Independent vessels, usually on long-time charter, in quasi-regular service	Freight, liquid cargo in full cargo lots	Specialized	3,000 to 15,000	10 to 16
Tramps	Independent vessels, on voyage or time charter, no fixed schedule or route	Freight, usually in full cargo lots	General	2,000 to 8,000	12 and under, usually about 10

[a]Prepared by M. Ogden Phillips, Wilson Professor of Economics, Washington and Lee University.



Schooner—American invention—most efficient sailing vessel. Work boat of the 19th century, almost extinct; fades away into mists of oblivion. ***Harvey Reeves***

oil as fuel accrued predominantly to the liner, but the tramp has suffered from the loss of many coal cargoes that formerly were carried to fueling stations throughout the world.

Various cargo developments have also contributed to the ascendancy of the liner. Following World War I, there was a great increase in hand-to-mouth buying in impoverished Europe, causing much grain, cotton, and lumber to move in parcel lots by liner. This tendency continued until the outbreak of World War II and was repeated after that war. For decades there has been a growing trend for raw-material-producing countries to ship manufactured or slightly processed goods instead of raw materials—for example, flour instead of wheat, quebracho extract instead of logs, and copper matte and blister copper instead of ore. Improved marketing methods have considerably reduced the seasonality in the movement of grain and other agricultural products, thereby reducing the need for the

TABLE 35:2. Prewar and Postwar Merchant Fleets of the World[a]

Country	Number	Gross tons	Number	Gross tons
	Sept. 1,1939		Dec. 31,1953	
United States	1,379	8,126,000	3,349[b]	25,835,000[b]
British Empire	3,319	17,771,000	3,017	19,075,000
Norway	1,072	4,499,000	1,020	6,093,000
Panama	130[c]	719,000[c]	540[c]	3,953,000[c]
France	555	2,678,000	600	3,523,000
Italy	667	3,178,000	556	3,342,000
Netherlands	537	2,670,000	498	2,987,000
Japan	1,180	5,102,000	567	2,973,000
Sweden	484	1,312,000	598	2,419,000
Germany	854	3,916,000	469	1,549,000
U.S.S.R.	354	1,136,000	504	1,528,000
Denmark	379	1,042,000	319	1,385,000
Greece	436	1,698,000	193	1,102,000
Spain	217	750,000	277	1,040,000
All others	1,235	3,673,000	1,863	8,298,000
World total	12,798	58,270,000	14,370	85,102,000

a Data include seagoing steam and motor merchant vessels of 1000 gross tons and over. Data exclude vessels on the Great Lakes and inland waterways and merchant vessels owned by any military force.

b Includes United States government-owned vessels transferred to foreign flags under lend-lease or other arrangements: 8 vessels of 27,000 gross tons to Philippines, 83 vessels of 518,000 gross tons to U. S. S. R.

c Chiefly vessels owned in the United States and Europe and registered in Panama.

Source: U. S. Maritime Administration.

flexible service of the tramp. Furthermore, the movement of many minerals has become so large and regular as to warrant the use of general cargo liners, specialty carriers, and industrial carriers. These changes have been accompanied by an increasing ability of the liner to approach tramp rates.

iron ore, bananas, meat, sulfur, bauxite, heavy steel, lumber, canned fish, and automobiles. We might almost say that the big company owns everything it needs.

The future lot of the tramp. While there are many forces that will contribute to the further ascendancy of the liner, it is not to

TABLE 35:3. Steam and Motor Vessels Owned and Registered in the United Kingdom, June 30, 1953, by Type and Propulsion

	Coal-fired steamers		Oil-fired steamers		Diesels		Total	
	No.	Thousand gross tons	No.	Thousand gross tons	No.	Thousand gross tons	No.	Thousand gross tons
Foreign-going								
Passenger-cargo liners	9	49	121	1,770	113	1,236	243	3,055
Cargo liners	64	241	459	3,050	327	2,082	850	5,373
Tramps	92	346	226	1,317	152	842	470	2,505
Tankers	...	...	132	1,302	325	2,622	457	3,924
Total	165	636	938	7,439	917	6,782	2,020	14,857
Coasting & home trade								
Passenger-cargo liners	37	36	60	140	38	51	135	227
Cargo liners	74	80	24	41	124	91	222	212
Tramps	425	463	33	28	267	171	725	662
Tankers	2	1	40	32	61	30	103	63
Total	538	580	157	241	490	343	1,185	1,164
Grand Total	703	1,216	1,095	7,680	1,407	7,125	3,205	16,021

This table relates only to trading vessels owned and registered in the United Kingdom. It excludes river and estuarial craft, tugs, cable vessels, fishing vessels, whalers, admiralty vessels, ships registered in the United Kingdom but owned abroad (about 1,000,000 gross tons), and vessels on bareboat charter returnable to other countries (6000 gross tons).

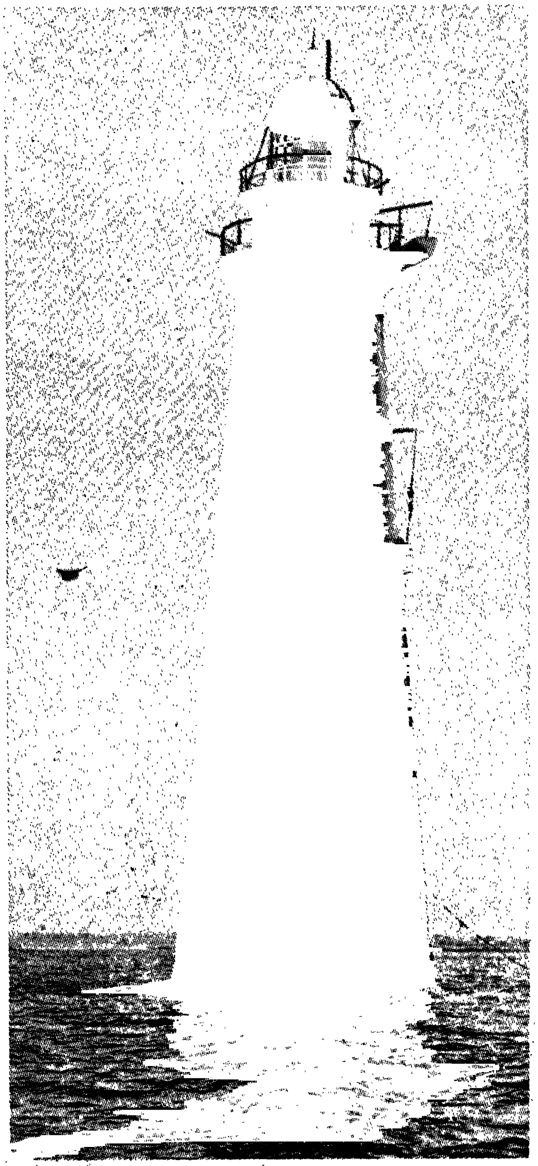
Coasting and home-trade vessels are those which usually trade entirely on the United Kingdom coast or within Elbe-Brest limits.

The usual employment of a vessel, as given by the owner, has determined its description as "liner" or "tramp." Passenger-cargo liners are those with accommodations for more than 12 passengers, all other liner vessels being treated as cargo liners.

Source: Chamber of Shipping of the United Kingdom, *Annual Report, 1953-1954*, London, 1954, Table 4, p. 150.

Not least among the factors contributing to the decline of the tramp has been the rise of the industrial carrier to a position of major importance in world shipping. The big corporation has often found it profitable to provide the transportation of its own products. Among the products now carried by industrial carriers are petroleum and other liquid cargoes, coal,

be assumed that tramp shipping is doomed. So long as heavy and bulky commodities must have cheap transportation, there will be a demand for the services of the economical tramp. So long as the demand for ship space is disturbed by such vicissitudes as wars, famines, plagues, earthquakes, locusts, droughts, strikes, bumper crops, and crop failures—and



Minots Ledge lighthouse, Massachusetts Bay. One of the many thousands of lights in houses, lightships, and on buoys on all frequented shores. Great traffic, many lights; little traffic, few. *U. S. Coast Guard*

so long as the movement of cheap and bulky cargo is subject to seasonality and irregularity —there will be a need for the flexibility of the tramp. The tramp will undoubtedly continue to decline in relative importance, but for some time to come it will continue to serve as the economical and ubiquitous factotum of the Seven Seas.

4. THE POSTWAR STATUS OF THE SHIPPING INDUSTRY

The impact of World War II upon shipping. World War II, like its predecessor, caused many dislocations in the world's merchant shipping industry.[12] The great German merchant marine was literally wiped out. The Japanese and Greek merchant fleets have not yet recovered from their wartime losses (see Table 35:2). Little Panama, a nonmaritime nation, has come to rank fourth in total tonnage, because American and European shipowners have registered vessels in Panama to take advantage of lenient laws regarding labor and taxation and to escape restrictions on trading with unfriendly nations during the Korean conflict. The Americans, British, and Norwegians now lead the world in number and tonnage of merchant vessels.

Although the United States has the world's largest merchant marine, American leadership in the shipping industry is by no means assured. Many American lines cannot exist without operating subsidies from the federal government. Long strings of Liberty ships lie idle in U. S. harbors, a "mothball fleet" held in reserve in case of another major war. While European shipyards have been busy turning out new ships since World War II, the output of our shipyards has declined. In 1953 American vessels carried about one third of all cargo in our ocean-borne foreign trade, as compared with 68% in 1946, less than 30% in 1931–40, and about 40% in 1921–30[13] (see Fig. 455).

As a result of wartime and postwar shipbuilding activity, the world had 47% more merchant vessel tonnage at the end of 1953 than in 1939. In April 1951 the Allied High

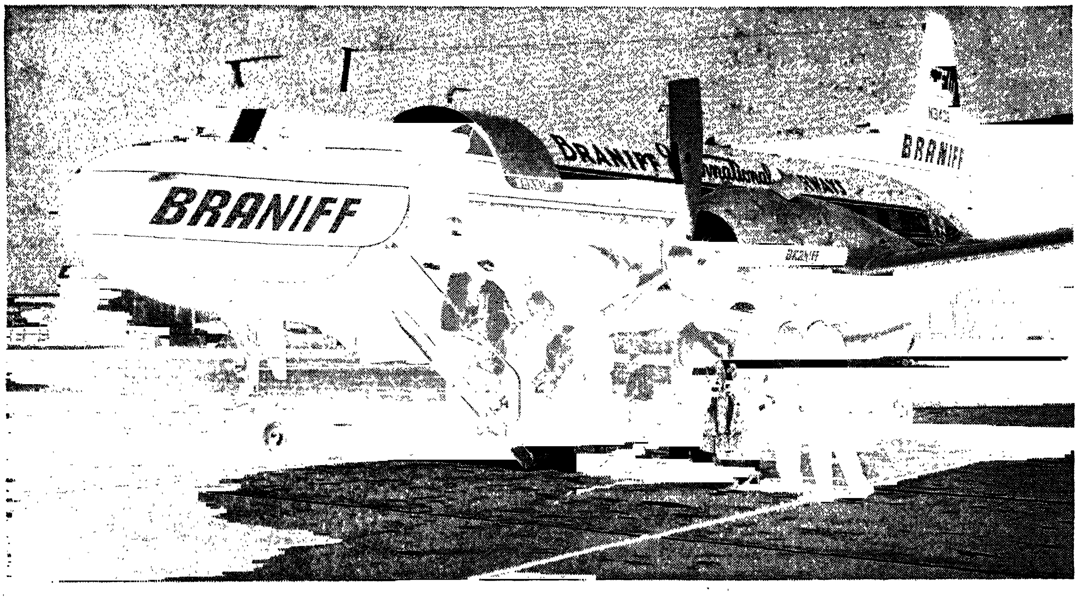
[12] For the consequences of World War I, see J. Russell Smith, *Influence of the Great War upon Shipping*, Oxford University Press, New York, 1919.

[13] During World War II, nine tenths of all men and three fourths of all cargo that left American shores were carried in American vessels. In the Korean crisis of 1950–53 the American shipping industry delivered more than 80% of logistical support materials to the Far Eastern theater.

Command removed restrictions on the size and speed of merchant vessels that could be built in West Germany. With the continued increase in vessel tonnage and the slow revival of world trade, competition for passengers and cargo in the postwar era has been exceedingly keen. The same thing happened after World War I.

Long-run trends. A number of significant trends may be observed from the experience of the merchant-shipping industry during the present century. The merchant vessel slowly but steadily becomes larger, faster, and able to do more work during the course of a year. Specialization in ship construction continues to increase. The liner gains dominance over the tramp. Petroleum increasingly displaces coal as marine fuel. Big corporations build more and more industrial carriers for the transportation of their own products. National governments continue to spend large sums of money on the subsidization of merchant marines.

Basic trends in the shipping industry are clearly revealed by the experience of Great Britain. At the outbreak of World War I, the British merchant marine used coal as fuel, while in 1953 about 90% of its total tonnage was propelled by oil. Although the British continue to operate the world's largest tramp fleet in competition with the Norwegians, Greeks, Italians, Dutch, and Japanese, they have shifted to liner tonnage (see Table 35:3). Between 1914 and 1953 the tramp's share of British merchant tonnage declined from 56% to 20%; the tanker's share increased from 8% to 25%; and the relative importance of liners, excluding tankers, increased from 36% to 55%.[14] Big British corporations are close rivals of the Americans in the ownership of tanker tonnage, and they own the largest fleets of ocean-going colliers, ore carriers, and refrigerator vessels. In contrast with most maritime nations, the British have operated their merchant marine with very little government aid.



"Who killed the Queen?" (p. 615). "I," said the plane. "I killed her with my speed." Water ships are too slow for the hurry of the Air Age. *Consolidated Vultee Aircraft Corp.*

14 See Franz Lohse, *Die Entwicklung der Trampschiffahrt in der Nachkriegszeit*, Dresden, 1934, pp. 13, 45, and Chamber of Shipping of the United Kingdom, *Annual Report 1953–1954*, London, 1954, Table 4, p. 150.

36· The World's Overseas Trade Routes

1. THE NORTH ATLANTIC ROUTE

Pre-eminence of this route. For more than a century the North Atlantic has been the busiest of the world's ocean trade routes. Probably one fourth of the world's merchant-vessel tonnage is employed on the North Atlantic. No other route equals this in volume and value of freight traffic, while the movement of passengers and mail across the Atlantic is larger than on all other routes combined. Upon this route new developments in ship construction almost invariably receive their ocean-going baptism. Here luxury, comfort, and speed are carried to a supreme degree. Here are to be found the world's largest and fastest passenger liners, the aristocracy of the shipping industry.[1] On no other route is competition among big shipping firms so keen.

Location factors. The North Atlantic route connects two continents that have long surpassed all others in manufacturing, transportation, finance, and trade. This route links western Europe and eastern North America, two very productive areas and the two greatest markets on earth. Between them there has long been a flourishing commerce based upon differences in resources, production, and needs. Shipping is merely the handmaiden of commerce, and many hundreds of vessels traverse the North Atlantic each year in the service of trade.

While the North Atlantic may seem to have a multitude of trade routes, there are certain geographical conditions producing a surprising similarity in the path followed by all of the ships that cross the ocean between North America and northern Europe.[2] An important factor leading to the use of this common path is what mariners call "the great circle." By examining a globe, one sees that in high latitudes the shortest line between any two points equidistant from the Equator is not on a parallel running due east and west, but along the arc of the circle passing through both the points in question and dividing the earth into two equal parts—a great circle.[3] The farther apart the two points in question are, and the farther from the Equator they are, the greater

[1] In 1954 only 11 ships exceeded 30,000 gross tons in size, as compared with 16 ships in 1939. The 83,673-ton *Queen Elizabeth* is the largest of all. These superliners are used on the transatlantic run.

[2] The ocean seems like a trackless waste, but if a considerable number of ships follow the same track for similar purposes during an appreciable period of time, we are justified in marking that path as a trade route. However, the thin lines on a map indicating the location of ocean routes do not have the same meaning. Each route has its own special character.—See Arthur J. Sargent, *Seaways of the Empire,* Adam and Charles Black, Ltd., London, 1930, p. 23.

[3] A circle upon the surface of a sphere is called a *great circle,* if its plane passes through the center of the sphere. The Equator and all meridians of longitude are great circles of the earth. To find the great-circle route between any two points upon the globe, simply stretch a string between the two points. A great-circle route is merely the arc of a great circle.

is the poleward curve of the shortest line between them. Hence, there are almost no straight east and west routes upon the charts used by the mariner. He is forever following curves. With the exception of the airplane pilot, the navigator of a ship is the one man who is most directly concerned with the fact that the earth is round.

It is rather astonishing to discover that the positively shortest air line from New York to Liverpool passes directly overland through New England and Canada west of Nova Scotia. The more closely ships approach this great circle, the shorter is their voyage. Consequently, as soon as it is safe to do so, all vessels leaving New York abandon their eastward course and swing northward along the line of a great circle, the exact point for this turn varying with the seasons. At all times of the year the vessel must proceed eastward before turning to the north, for it is by this means that navigators avoid the Newfoundland fog banks. East of Newfoundland all vessels from New York, Boston, Halifax, and Montreal join the stream of traffic that follows the great-circle route across the Atlantic to the ports of northern Europe.

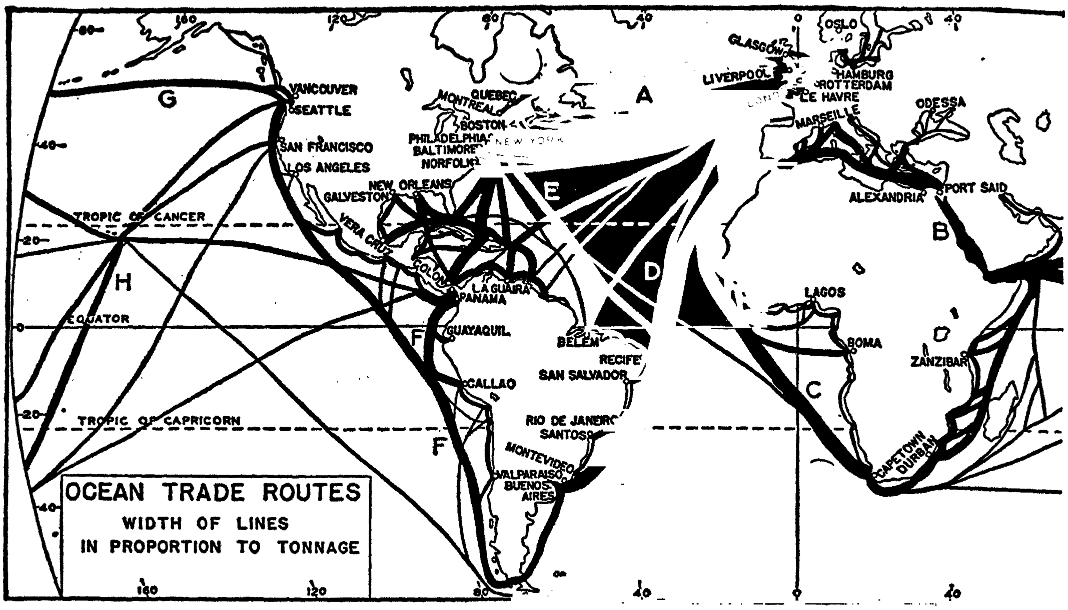
From Florida to Newfoundland the North American coastline extends from southwest to northeast, and this coastline is practically a part of the great-circle route to Scotland. Consequently, all ships leaving our South Atlantic ports, the Gulf of Mexico, and the Caribbean coast of Central America follow the coast and join the same path used by vessels leaving our North Atlantic ports. Indeed, it is but 323 miles farther from Greytown, Nicaragua, to Liverpool via New York than by the shortest possible great-circle route. Therefore, ships sailing northward from the Caribbean can well afford to call at our eastern ports for way-cargo en route to Europe. It is clear that the North Atlantic route is a great trunk route with a string of branches for the many ports between St. Johns, Newfoundland, and Colón, Panama. At its eastern end this route serves European ports from Archangel to Gibraltar.

Navigation hazards are an obvious factor affecting the course of an ocean vessel. The North Atlantic route is almost devoid of reefs and shoals. Notable exceptions are Sable Island—the so-called "graveyard" of the Atlantic—east of the Maine coast, and a few small rocks in the Grand Banks. Navigators aim to clear these dreaded landspecks by about 60 miles and to avoid the almost continuous fogs in the Grand Banks area caused by the intermingling of the cold Labrador Current with the warm Gulf Stream. Another danger spot is Cape Hatteras on the North Carolina coast. Because of long strings of sandbars reaching out to sea, this cape must be rounded with caution. Many a good ship has ventured too near these bars and met a watery doom.

A serious menace to navigation is the danger of collision with icebergs, which break off the Greenland glacier and drift southward from the middle of March until late in July. Icebergs are especially dangerous south of the tail of the Grand Banks, where there is greater congestion of shipping. Only one ninth of an iceberg appears above the surface of the sea, and the U. S. Coast Guard patrol has reported some icebergs as long as 1690 feet and rising 250 feet above the water. It was an iceberg that sank the crack White Star liner *Titanic* in April 1912, with a loss of 1517 lives. Since then shipping lanes have been shifted 2°30′ farther south during the iceberg season, and our Coast Guard patrol boats send out warnings by radio reporting the location of large icebergs.

Since the cost of fuel is the largest single item in vessel operating expense, the availability of fuel is one factor determining the desirability of an ocean route. More than 80% of the world's merchant vessel tonnage is propelled by oil.[4] Eastern America and western

[4] Oil has advantages over coal. Ton for ton, oil has one third more heating value, and perfect combustion is possible. Labor costs in the engine room are much lower. Fuel oil and Diesel oil can be loaded four or five times faster than coal, and much of it can be stored in the ship's double bottom, making more space available for cargo. Hence, the oil-burning steamer and the Diesel-engined vessel, or motorship, can make much longer voyages than the coal-burning steamer without refueling. Oil will continue to be the favored marine fuel as long as it remains plentiful and cheap.



Europe are well supplied with oil-bunkering stations. Oil from the Midcontinent and Gulf fields is delivered cheaply to our Gulf and Atlantic ports, and oil is abundant and cheap in the Caribbean area. Western Europe, however, is oil-poor and imports most of its oil from the Middle East and the Caribbean region. Since fuel oil is more costly in Europe, oil-burning liners leaving North American ports usually carry enough bunker fuel for the round-trip.

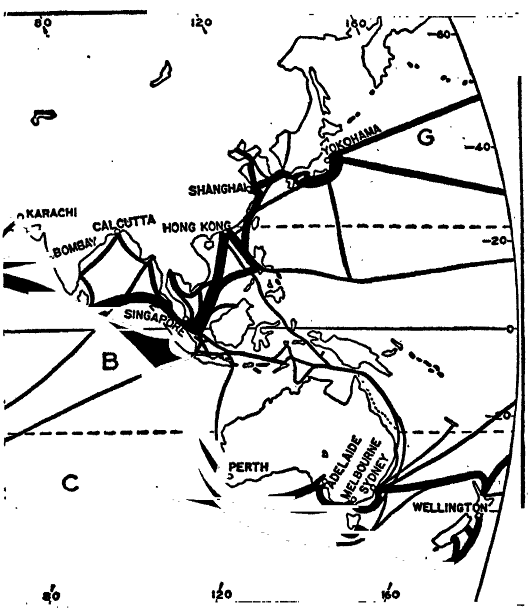
No route equals the North Atlantic in the abundance, cheapness, and quality of its coal supply. In western European ports, steamers can obtain British or German coal; in Baltic ports, Polish coal; in Canadian ports, Nova Scotian coal; and in U. S. and Caribbean ports, the coal of Appalachia.

Passenger and mail traffic. From the first settlements at Jamestown and Plymouth until the enactment of a law in 1924 drastically restricting immigration, America was the mecca of European home seekers, and the North Atlantic was the world's greatest immigrant route. From 1880 to 1924 approximately ½ million Europeans packed the steerages of transatlantic vessels every year en route to new homes in the United States. In the first decade of the twentieth century more immigrants landed on American shores than in all the years prior to 1850. Although immigrant fares were low, the total income to passenger lines was large.

Following the curtailment of immigration in 1924, some lines were forced into bankruptcy. To stimulate new business, the transatlantic passenger lines were obliged to cater to the tourist trade by making comfortable accommodations available at reasonable rates. The poor and ambitious immigrant of former years is now replaced by the college student and others of ample means who spend a vacation in Europe. The passenger traffic is distinctly seasonal, reaching a peak during the summer months.

Passenger liners carry mail, express, and small amounts of high-valued freight. Mail services on the North Atlantic have long been faster, more frequent, and more heavily subsidized than on any other route. The coming of regular transatlantic airplane service presented a new problem for the passenger lines, because mail, express, and much passenger traffic began deserting the ocean liner for the much faster liner that flies through the air. More than one half of all tourists now go to Europe by airplane.

Freight traffic. Year after year the tonnage of eastbound freight on the North Atlantic is three or four times larger than westbound



Look at this map often as you read the various sections of this chapter. What makes each particular line as it is? The major overseas trade routes portrayed by the map are as follows: (A) North Atlantic, (B) Mediterranean-Asiatic-Australasian, (C) Cape of Good Hope, (D) European-eastern South American, (E) eastern North American-eastern South American, (F) North American-western South American, (G) North Pacific, (H) North American-Australasian. *C. F. Jones and G. G. Darkenwald, Economic Geography, The Macmillan Co., New York, 1954, p. 553*

freight. Shipments from Europe to North America consist chiefly of manufactures and other commodities of high value and small bulk that move in parcel lots by liners. On this route British coal exports are insignificant, for the United States and Caribbean lands are well supplied with American coal. The westbound tramp occasionally is able to obtain a full cargo of Spanish pyrites, French chalk, German potash, Scandinavian pulp or newsprint, or British china clay, but usually the tramp that clears a European port for Canada or the United States must move in ballast.

On the other hand, there is an enormous movement of foodstuffs and raw materials to Europe: grain, lumber, wood pulp, and dairy produce from Canada; iron ore from Newfoundland; petroleum, sugar, fruit, and hardwoods from the Caribbean; and petroleum, iron and steel scrap, phosphate, sulfur, cotton, grain, meat, apples, and other commodities, together with large shipments of manufactures, from the United States.

This lack of balance between eastbound and westbound traffic has definite effects upon the shipping industry. The liner is tied to its route and must leave on schedule. On westbound voyages most of its cargo space is empty. Hence, it is forced to charge higher rates on eastbound cargo than if westbound cargo were available. On the other hand, the tramp may travel from Europe directly to North America in ballast, but it has an alternative—the triangular voyage. The tramp can often carry British coal to Argentina and Brazil. It may pick up a cargo of Argentine flax or Brazilian manganese or some other commodity, or it may move in ballast to Chile for a load of nitrate and carry it to the United States, where cargoes for Europe can be obtained.

On no other route has the tramp suffered so acutely from liner competition as on the North Atlantic. Since 1913 the tramp has steadily lost ground in the carriage of grain, cotton, lumber, phosphate, sulfur, and other bulk commodities.[5] These desertions from tramp to liner reflect the tremendous volume and growing regularity of cargo movement from the United States and Canada to Europe. The North Atlantic is not only the passenger liner route par excellence. It is the best of all routes for cargo-liner service.

The future. For many decades prior to World War II, Europe remained the largest

[5] See *Report of United States Maritime Commission on Tramp Shipping Service,* 75th Congress, 3d Sess., House Document 520, Washington, 1938.

market for American exports and the leading source of our imports. In both prewar and postwar eras, approximately one third of our exports to Europe and one third of our imports from Europe have consisted of finished manufactures, the remainder being foodstuffs, raw materials, and semimanufactures. For many years our trade with Europe continued to increase, although declining in relative importance as our trade with other countries increased (see Figs. 551, 554, and 558).

Europe is recovering from the disastrous effects of World War II, and European and American manufacturers are again competing for the world's raw materials and markets. The highly industrialized nations of western Europe can continue to buy foodstuffs and raw materials only if they can sell their manufactures and services to others. The future of trade and shipping upon the North Atlantic therefore depends not only upon what happens in Europe but upon events in the rest of the supposedly civilized world.

2. THE ROUTES OF CARIBBEAN AMERICA

Unusual features. Although most inbound and outbound traffic of Caribbean America is handled over extensions of the North Atlantic route, there are reasons for placing the routes of this region in a separate class. First, the routes of the Gulf of Mexico and Caribbean Sea do not form a trunk-line route. Within this area there is a veritable tangle of routes that crisscross each other in many directions. Second, liner traffic within this area is difficult and costly to work, because there are many small ports of call. Third, most of the region's commerce is not across the Atlantic but with the United States. And, fourth, this region has two routes to Europe, a front door and a back door.

The front-door approach to Europe is by way of the great North Atlantic circle. The back door leads to a longer route via the Azores, and liner traffic on this route is worked in a semicircular manner. For example, the vessels of one British line leave Southampton and call at the Azores, Bridgetown, Port-of-Spain, Barranquilla, Cartagena, Colón, Kingston, Antilla, New York, and Montreal. Then they retrace the route to Great Britain, calling at the same ports but in the reverse order. Likewise, a Dutch line routes its ships from Amsterdam via the Azores to the Guianas, Venezuela, the Lesser Antilles, and New York, the vessels returning to Europe by the same path—a horseshoe or semicircular route.

Outbound and inbound traffic. The volume of exports from the Gulf and Caribbean area greatly exceeds the volume of imports. Many tankers are needed to handle the huge shipments of petroleum and its products from Venezuela, Trinidad, Colombia, and Mexico. After sugar cane is harvested, tramp ships swarm to Cuban and other West Indian ports to carry away raw sugar. Throughout the region tramps obtain occasional cargoes of hardwood, tropical fruit, and fibers. Industrial carriers owned by big U. S. corporations carry away Cuban and Venezuelan iron ore, Guianan and Jamaican bauxite, and Central American bananas. Coffee, cacao, henequen, various ores, and virtually all commodities except sugar are handled predominantly by vessels operating on regular liner schedule. By far the lion's share of the region's export trade is with the United States.

The tropic lands of Caribbean America import wheat, flour, meat, pine lumber, coal, and a great variety of manufactures from the United States. Smaller quantities of manufactures are purchased from Great Britain and continental Europe. This is liner traffic. American manufactures, coal, politics, and financial investments have long dominated the region. It is not without reason that the waters of the Gulf and Caribbean are known as "the American Mediterranean."

3. THE EAST- AND WEST-COAST ROUTES OF SOUTH AMERICA

Location and importance of the east-coast route. One of the world's great trade routes links the agricultural and pastoral nations of Argentina, Uruguay, and Brazil with the

fruits, carnauba wax, hardwoods, and rubber.

The United States, with its huge consumption of coffee, has long been Brazil's leading foreign market, yet two thirds of all Brazilian exports are destined for Europe. In postwar years more than one half of all Brazilian imports have come from the United States. Although Brazil and Argentina have made remarkable progress in the development of local manufacturing industries, both countries continue to import a wide assortment of manufactured goods from the United States and Europe.

Brazil, Uruguay, and Argentina are vitally dependent upon foreign supplies of bunker fuel. As the world's merchant marines turned to the use of oil as fuel, South American imports of British coal declined from 6.9 million tons in 1913 to 2.8 millions in 1938, and to 0.6 millions in 1953. Although Argentina has developed her oil fields intensively, production does not meet domestic needs, and all three of these South Atlantic countries import large quantities of fuel and Diesel oil, chiefly from Caribbean refineries.

Importance of the Panama Canal to west-coast trade and shipping. Although the west-coast route of South America is not so important as the east-coast route, traffic along the Pacific coast has increased greatly since the opening of the Panama Canal in 1914. The canal eliminated the long voyage via the Strait of Magellan and made Pacific ports 2000 to 8000 miles nearer the great industrial nations of the North Atlantic. Many new liner services were established between the west coast and eastern United States and western Europe via Panama. The reduction of transportation costs and a speedier delivery of goods stimulated the mineral, agricultural, and pastoral industries of Pacific South America.

A glance at a map of the world reveals that much of the west coast of South America lies almost due south of New York. It is surprising how much of the voyage between eastern American ports and those of Pacific South America approximates a direct route along the 75th meridian, W. Long. The opening of the Panama Canal made the entire west coast of the South American continent much nearer to eastern United States than to western Europe. The canal made possible a great increase in trade between eastern United States and the Pacific coast of South America.

The nature of west-coast traffic. West-coast countries, like those that face the South Atlantic, import many manufactures from eastern United States and western Europe. Minerals, however, play a major role in the export trade of the west coast. Only Ecuador is mineral-poor. Minerals account for 35% of the total value of Peruvian exports, 80% of Chilean exports, and over 90% of the exports of Bolivia. Whereas grain is the great tramp cargo of the east coast, Chilean nitrate shipments provide the chief employment for tramps along the Pacific. Nearly 2 million tons of sodium nitrate move through the ports of Antofagasta and Iquique each year, tramps handling about two thirds of this trade.

With few exceptions, other west-coast cargoes are handled by vessels operating on regular liner schedule. Bethlehem Steel Co. carriers move about 3 million tons of iron ore annually from Cruz Grande, Chile, to the company's steel plants at Sparrows Point, Md., and Standard Oil tankers carry away over 325,000 tons of petroleum from the Peruvian port of Talara. Liners handle Colombian coffee, Ecuadorean cacao, coffee and bananas, most shipments of Peruvian cotton and sugar, the wool exports of every Pacific country, and the high-valued minerals that come down from the Andes, namely, copper, tin, lead, zinc, vanadium, antimony, silver, and gold. The great majority of all ships engaged in west-coast trade fill their bunkers with Caribbean and Peruvian oil.

4. THE MEDITERRANEAN-ASIATIC ROUTE

Lands and peoples served in this route. The Mediterranean-Asiatic trade route pierces the heart of the world, for it serves most of the land area and most of the world's population. The major parts of the land hemisphere

are connected through their midst by this great route and its main ramifications. An examination of the globe shows how great a part of the world it reaches. Asia itself comprises more than a third of the land surface of the earth. With Europe and Africa, which are a part of the same land mass, it comprises much more than half the earth's land. Mackinder calls it the "World Island" (see Fig. 571).

By one of the fortunate circumstances of geography, this route pierces the middle of this world island and land hemisphere and practically circumnavigates the vast, irregular continent sometimes called Eurasia—much the greatest block of land in the world—and receives branches from all the numerous indentations that cut its southern shore. The vast size and mountainous interior of these lands reduce land transportation to insignificant proportions and turn all traffic toward the sea. The great land mass of Eurasia has about 1900 millions of people, Atlantic North America has over 180 millions, and Africa contributes enough to raise the total of the people served by this route to well over 2100 million —an astounding figure. The total population of the world is about 2500 million, so the Mediterranean-Asiatic route serves perhaps three fourths of the world's inhabitants.

This route connects two great types of Western civilization (as represented by Europe and America) with the Orient and its older civilizations of India, China, and Japan. Along the route is found every stage of industry—the most complicated and mechanical in America and Europe, the most elaborate hand manufactures of India and the Orient, and the crudest producers of crude raw materials, such as the salt gatherers on desert coasts.

The route may properly be described as being double at both ends. In the west it has its main feeders in Europe, but an important part also on the Atlantic coasts of America. In the east, after rounding the continent of Asia, one large division turns to the northeast toward China and Japan, while another important branch goes to the southeast to serve Australia.

A trunk-line route. Of all the world's ocean routes, the Mediterranean-Asiatic is the trunk line par excellence. This comes about from its length and its location between the two northern and the two southern continents of the Eastern Hemisphere, which it serves by numerous lateral branches, finally reaching in the west the United States and Canada, where its termini include the widely separated points of Houston and Montreal. The indented coasts of Europe and Asia furnish from every great gulf and sea a branch to the main trunk route. In this respect, it is quite the peer of any railroad system and in its structure bears considerable resemblance to the Pennsylvania Railroad—probably the best located railroad with regard to freight traffic in the whole world (see Fig. 628–629).

The distribution of bunker fuel. With the exception of its extremities in western Europe and eastern Asia, the Mediterranean-Asiatic route is well supplied with oil fields. Adjacent to this route are the oil fields of the United States, Caribbean America, Rumania, Russia, Iraq, Saudi Arabia, Bahrein Island, Iran, Kuwait, Burma, Indonesia, and British Borneo. Only the west coast of Europe and the east coast of Asia are dependent upon distant supplies. Oil fuel stations are more numerous than coaling stations today, and ships that traverse this route have no difficulty in filling their bunkers with the liquid fuel.

The far-flung Mediterranean-Asiatic route is well endowed with coal fields at its extremities, but for thousands of miles its middle part is peculiarly barren of coal except in India. At the Atlantic termini are the coal fields of eastern United States, Nova Scotia, Great Britain, and Germany. Along the Pacific are the coal fields of Japan and eastern Australia, together with the vast but little used reserves of China. Between its Atlantic and Pacific termini this route is dotted with coaling stations supplied with imported fuel.

Although British coal dominates the Mediterranean, it has almost disappeared at coaling stations east of Suez. Indian Ocean ports now receive virtually all their bunker coal from

South Africa and Australia. Singapore and coaling stations to the east are supplied with Australian and Japanese coal. Of the many coaling stations along the route, three are of outstanding importance: Port Said at the Mediterranean entrance to the Suez Canal, Colombo at the crossroads of the Indian Ocean, and Singapore on the strategic Strait of Malacca.

Six major traffic divisions. The traffic upon this great route, which almost circumnavigates the world, is as varied as the peoples and lands that it reaches. For convenience the traffic may be considered in six different groups. While two of these groups are confined to a single continent each, and in that respect have certain local aspects, their trade is international.

(1) The first of the six major traffic divisions includes the waters of the Mediterranean and Black Seas. This traffic is between two distinct economic districts—a food- and raw-material-importing district and a food- and raw-material-exporting district. Although France and Italy are great agricultural countries, they are not self-sufficient. Furthermore, their factories need raw materials. Among the principal westbound cargoes are Middle Eastern oil, which has been delivered by pipelines to the ports of Lebanon and Israel for re-export; Russian grain and manganese; Yugoslavian corn; Turkish cotton, tobacco, and chromite; and the wool, hides and skins, and other products of the eastern Mediterranean. This gives the basis of a lively exchange of manufactures from the west for the food and raw materials of the east.

(2) The second major division of traffic is trade between western Europe and the Mediterranean. Great Britain and the other countries adjacent to the North Sea use great quantities of the subtropical orchard and garden produce grown along the shores of the Mediterranean proper, from Spain to the Near East inclusive. Chief among these products are wine, oranges, lemons, figs, raisins, olives, and early vegetables. The countries of northwestern Europe are also large importers of North African phosphate, Sicilian sulfur, Egyptian cotton, and the foodstuffs and raw materials of the eastern Mediterranean and Black Sea region. The return cargoes in this trade consist in point of bulk primarily of coal, of which about 4 million tons a year pass from the Welsh fields to the Mediterranean ports. The next in bulk are the forest products of Scandinavia, which are in great demand in the populous and essentially timberless Mediterranean. In point of value these bulky articles are rivaled by the machinery, cottons, and other manufactures of Great Britain, France, Belgium, and Germany.

(3) A third major traffic division consists of trade between the countries of southern and eastern Asia, known as the Far East. Here is a large traffic and one which promises to continue its growth, for it has a firm basis in economic conditions. Japan before World War II had become a rapidly increasing importer of food and raw materials. Chief among these imports were rice from Burma, Thailand, and Indochina; raw cotton, jute products, and pig iron from India; sugar from Formosa and Java; and iron ore from Malaya and the Philippines. In return for these commodities Japan sent coal as far as Singapore, and manufactures (chiefly cotton goods) to all the countries mentioned. If Japan resumes her industrial expansion, and China with her vast population follows in her wake, this trade between temperate Asia and tropic Asia may increase greatly.

(4) Trade between North America and the Mediterranean is a fourth division of traffic, which at one time was handled as entrepôt trade through London. From the Mediterranean region the United States now imports directly such products as olives, olive oil, wine, raisins, currants, and sardines in addition to considerable quantities of Portuguese and Spanish cork, Spanish fluorspar, pyrites, and iron ore, Egyptian cotton, Turkish tobacco, and Russian manganese. In volume and weight these imports greatly exceed our exports, which consist chiefly of machinery and other manufactures and raw cotton.

(5) Trade between Europe and the Orient, the fifth major group of traffic, is the oldest trade along this route. It began long ago with an exchange of European bullion for the silks and other luxuries of the skillful East. The region of the Persian Gulf now sends to Europe oil, dates, wool, and hides as well as Mohammedan prayer rugs. The port of Karachi in West Pakistan once was famous for huge shipments of wheat, but this trade has virtually ceased. Beyond is Bombay, which sends to Europe cotton, hides, and a great variety of oil seeds, including peanuts, castor beans, and linseed, which have many industrial uses. Vizagapatam on the east coast is one of the world's largest shippers of manganese ore. Both Colombo and Calcutta are great exporters of tea. From Calcutta also comes the world's supply of jute for bags and burlap, and also much hemp and coir fiber.

Burma, Thailand, and Indochina have as their staple export, rice, which is sent in shiploads to Bremen and London, the great European rice markets. Singapore is the assembling point for the world's natural rubber, a shipper of tin, and a great spice center. From Indonesia come sugar, spices, tobacco, coffee, copra, and tin. The Philippines send Manila hemp, copra, and coconut oil. Japan ships raw silk and some tea.

In return for this varied supply of raw materials and peculiar manufactures, western Europe (chiefly Great Britain) is sending iron and steel products, locomotives, all kinds of machinery, cotton goods, clothing, chemicals, and manufactures and supplies in innumerable variety.

(6) Finally, there is a sixth group of traffic between eastern North America and the Far East. This trade was handled as entrepôt trade through London until about 1900, when the first steamship lines were established between New York and the Far East. The opening of the Panama Canal created a shorter route between eastern America and Japan, the Philippines, and the China coast north of Hong Kong, but our trade with the rest of Asia continues to flow through Suez. Westbound traffic along the Mediterranean-Asiatic route consists chiefly of rubber, tin, rice, fibers, tobacco, and spices from southeastern Asia, jute bags, manganese, and shellac from India, and the tea of India and Ceylon. Eastbound traffic includes motor vehicles, machinery, petroleum products, and many other manufactures.

Significant traffic changes since World War I. Several important changes in traffic conditions occurred along the Mediterranean-Asiatic route in the interim between World Wars I and II, most of them contributing to the decline of tramp shipping. First, there was a great decline in the importance of the "Big Triangle"—a lucrative trade involving the movement of tramps with coal from Great Britain out to Italy and Mediterranean coaling stations, on to the Black Sea in ballast, and back to northwestern Europe with grain. British coal exports to the Mediterranean region declined from 12 million tons in 1913 to 5½ millions in 1938, and to 4 millions in 1953. Russian wheat exports in the 1930's were less than one third of their 1909–13 volume. In 1952 the total grain exports from the Soviet Union to West Europe were about equal to those of 1934–38, but grain exports from the Danubian countries, excepting 440,000 metric tons of Yugoslavian corn, were very small (see Table 36:1). Second, American exports of cotton, wheat, and lumber declined sharply. Third, Indian wheat exports, which averaged 50 million bushels a year in 1909–13, and only 3 million bushels in 1930–38, are virtually non-

TABLE 36:1. West Europe's Gross Imports of Grain from the U. S. S. R. and Danubian Countries (thousands of metric tons)

Country of origin	1934–38 average[a]	1951	1952
U. S. S. R.	1184	1363	1461
Yugoslavia	438	44	454
Czechoslovakia	218	73	113
Hungary	574	112	97
Rumania	1301	85	77
Bulgaria	118	9	43

[a] Prewar boundaries.
Source: Adapted from Lois Bacon, "Europe's East-West Trade in Food," *Foreign Agriculture,* July 1954, p. 132.

existent today. Fourth, liner shipping captured nearly all the Indian jute trade and more than half the Burma rice trade. Fifth, the sugar exports of Java came to be handled almost entirely by liners and have greatly declined since World War II.

On the other hand, several developments provided new traffic for tramps. As a consequence of industrial expansion, Russia began to make large shipments of pig iron to Japan and railway materials to eastern Siberia from its Black Sea ports in the interim between world wars. India became the world's greatest exporter of pig iron, more than one third of her output being shipped to Japan, Great Britain, and the United States at the outbreak of World War II. The greatest of all developments, however, favoring the tramp was the tremendous increase in soybean exports from Manchuria. Between 1911–13 and 1936–39 the average annual exports of soybeans increased from 196,000 to more than 2,000,000 tons. Approximately two fifths of these soybean exports were carried by tramps from Manchuria to Europe, and many of the tramps were able to return directly to the Far East with full cargoes of German potash salts for Japan.

Lumber from U. S. Gulf ports swings off at Durban, South Africa. See three bundles coming off. *Lykes Bros. S. S. Line, Inc.*

A number of developments since World War II have dislocated trade and shipping along the Mediterranean-Asiatic route. The creation of an "Iron Curtain" by the despots in Moscow has divided Europe into two separate entities, greatly reducing the commerce of the free nations of the West with Russia and her satellites. Likewise, the establishment of a Communist regime in China has caused the overseas trade of that unhappy nation to decline, for the present at least. The postwar partition of the subcontinent of India into two rival nations has dislocated both internal and external trade. The establishment of the Republic of Indonesia and the readjustment of the Japanese people to a new political environment are reflected in the export and import statistics of these nations. In this troubled postwar era it is indeed unlikely that the world will witness another golden age in overseas trade and shipping such as prevailed between the Napoleonic Wars and World War I, an era of commercial expansion and world peace.

5. THE SOUTH AFRICAN ROUTES

Location factors. The Cape of Good Hope is a focus of trade routes that connect western Europe and eastern North America with the southern and eastern coasts of Africa and that link western Europe via the Cape with Indonesia and Australia. Two of these routes, therefore, are through-traffic routes around the Cape, leading to Indonesia and Australia and serving as detours around the tolls at Suez. Ships engaged in all four trades join in one big stream of traffic between the Cape Verde Islands and the Cape of Good Hope. Offshoots from this common path lead to the small ports of West Africa (see Fig. 628–629).

Great-circle sailing is important on all four South African routes. Ships bound for Capetown from New York follow a great-circle route that skirts the Cape Verde Islands. Those leaving the English Channel pass through the Canaries and must clear the "shoulder" of Africa before joining the great-circle traffic into Capetown. Great-circle routes

are commonly used between South Africa and Indonesia. On the Capetown-Melbourne circle ships must deviate from the middle portion of the circle, because it curves far southward into dangerous storms and ice.

Strong westerly winds, known as the Roaring Forties, are important to shipping on the South African-Australian route. On the eastbound voyage the ships have the wind behind them. On the westbound voyage they usually follow a more northerly and longer route to Durban, thereby avoiding the full force of the wind and saving fuel. In the halcyon days of the sailing vessel, many ships proceeded eastward from the Cape to Australasia and thence to Cape Horn en route to Europe or eastern America. Such ships were said to "round the Cape and double the Horn." Indeed, as much as 40% of Australian wheat exports were carried by sailing tramps prior to World War I.[6]

All the terminal areas served by the South African routes have local supplies of bunker coal, but western Europe, South and East Africa, and Australia must depend upon imported oil. At Durban and Capetown steamers obtain the high-grade coal of Natal. Capetown has become an important oil fuel station dispensing oil from the Caribbean and Middle East. Since oil has become the dominant marine fuel, the sale of British coal at the Canaries and Cape Verde has declined.

Traffic characteristics. Tramps, general cargo liners, and refrigerator vessels operating between Australia and western Europe follow the Cape of Good Hope route in preference to Suez. The voyage from Sydney to Liverpool is only 1000 miles longer by the way of the Cape than via Suez. The Cape route, with its long voyage through the southern Indian Ocean, is a cooler route, involving less expense in the operation of refrigeration machinery. It is decidedly the cheaper route, saving the tolls and delay in passage through Suez. Along the Cape route move large quantities of grain, flour, meat, butter, fruit, hides and skins, various ores, jarrah wood, and other Australian products in exchange for European manufactures. Only passengers, mail, express, gold, and usually wool move via Suez.

More Indonesian than Australian trade is routed through the Suez Canal. Batavia is 2700 miles nearer to Liverpool via Suez than by way of the Cape. However, the economy of the Cape route attracts tramp ships, which carry cargoes of Indonesian sugar, copra, tapioca root (cassava), and cordage fibers to the markets of western Europe.

The old adage that "good things come in small packages" is true of the South African export trade, which is almost entirely in the hands of liners. South African exports include copper, diamonds, ostrich feathers, meat, wool, mohair, hides and skins, corn, cane sugar, and wattle bark and extract, but the greatest of all exports is gold. In fact, the value of gold shipments exceeds the value of all other exports. Only occasionally do tramps obtain cargoes of hides and skins, corn, and wattle bark at South African ports. East African cotton, oilseeds, and ores are handled by liners. To South and East Africa come many parcels of European and American manufactures, shipments of Caribbean oil, and pine lumber from our Gulf coast.

6. TRANSPACIFIC ROUTES

The New Zealand-Cape Horn circle. Four great circles provide the key to an understanding of transpacific trade and shipping. Least important of these great-circle routes today is the old sailing-vessel route between New Zealand and Cape Horn. The eclipse of the sailing vessel by the coal-burning steamer and the opening of the Panama Canal virtually killed all traffic along this route. Only a few lonely tramps carry occasional cargoes of Australian coal to Chile, where they may pick up a load of nitrate or else proceed to the Plata estuary in ballast for grain.

[6] A statement by one of the largest wheat exporters in Australia. Letter of August 22, 1935, from Albert M. Doyle, American Consul, Sydney, Australia.

The New Zealand-Panama circle. The opening of the Panama Canal gave birth to a new route extending from the canal past the Galapagos Islands and across the South Pacific to New Zealand, with branches to Sydney and Melbourne, Australia. Over this route and through the canal moves the entire trade of Australia and New Zealand with eastern North America and also the trade of New Zealand with western Europe. This trade consists of an exchange of pastoral and agricultural products of Australasia for American and European manufactures, and it is handled almost entirely by liners.

Coal-burning steamers have no problem in obtaining cheap bunker coal at the North Atlantic and Australasian termini of this route, but oil-burning steamers and motorships do not bunker in Australasian ports unless necessary. Fuel and Diesel oils imported from Indonesia and Iran are costly. Indeed, motorships now make the 19,400 mile round-trip from New York to Sydney and back to New York with only one bunkering, namely, at Panama.

The New Zealand-Puget Sound circle. Honolulu is a focus of routes linking Australasia with the west coast of Canada and the United States. One great-circle route extends from Vancouver through Hawaii to the Fiji Islands, where the route branches off to Auckland and Sydney. Most vessels leaving American west-coast ports converge at Honolulu and follow a great circle through Samoa to Auckland and thence to other Australasian ports. Through-liner traffic is light, consisting of southbound paper products and miscellaneous manufactures, and northbound wool, butter, and hides and skins. The only bulky commodity is Puget Sound lumber, which moves by tramp to Australia.

The North Pacific circle. Greatest of transpacific routes is the one that links western United States and Canada with Japan, the Philippines, and the eastern Asiatic mainland. An examination of the globe reveals that North America and Asia really do not face each other across a wide ocean but that the west coast of our continent and the eastern shores of Asia are practically a continuous straight line (see Fig. 639). Hence, vessels leaving San Francisco can follow a great-circle route past the barren Aleutian Islands to Yokohama and Manila, with branches reaching to many ports on the Asiatic mainland. In practice, transpacific liners call at Puget Sound ports and then make the 4300-mile voyage to Yokohama. The North Pacific has no icebergs, but severe storms in winter cause steamship lanes to be shifted south of the usual route.

Only the globe reveals that a great circle between Panama and Yokohama passes northwest through the Caribbean Sea, Yucatan, Texas, Wyoming, Vancouver Island, the Alaska peninsula, and thence southward to Japan. Obviously, such a direct route is available to an airplane but not to an ocean vessel. Ships from Panama must skirt the west coast of Central America and Mexico until southern California is reached, and they could follow a great circle to Japan crossing mid-ocean in the latitude of southern Canada. To stop at San Francisco would require a deviation of only 114 miles, as compared with a deviation of over 300 miles via Hawaii. Consequently, vessels coming northward from Panama find it worth while to stop at leading west-coast ports to pick up way-cargo.

The North Pacific route is by no means so well endowed with coal as the North Atlantic. Bunker coal is mined on Vancouver Island and in Japan. Oil fuel stations along the west coast of North America have easy acess to California oil. Eastern Asiatic ports depend upon oil imported from the United States, Iran, and Indonesia.

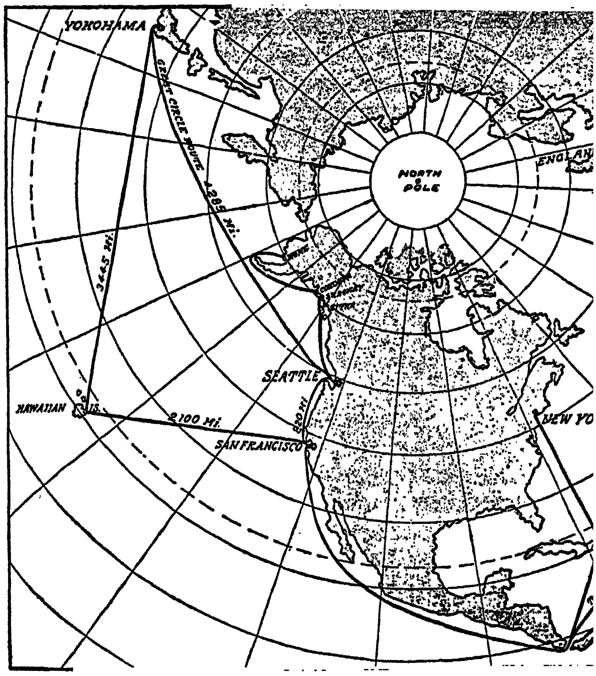
Traffic on the North Pacific route may be divided into two major streams. The first and more important consists of vessels operating between the west coast of the United States and Canada and the countries of eastern Asia. The second consists of ships that operate between our Gulf and Atlantic ports and the Far East via Panama and which call at our west coast ports en route. In each case the tonnage of westbound cargo far exceeds eastbound.

Vast quantities of lumber, wood pulp, paper, scrap metal, and usually wheat and flour are shipped to eastern Asia from Washington, Oregon, and British Columbia. California exports some oil and provides such dry cargoes as scrap metal, fertilizer, cotton, canned fruit, and salt. From our Gulf ports are shipped large quantities of cotton, phosphate, sulfur, and some scrap metal, while our Atlantic ports export scrap metal, heavy iron and steel products, and a wide assortment of manufactures.

In contrast, much smaller quantities of Philippine copra, sugar, hemp, and vegetable oils are about the only bulky cargoes moving eastward. Virtually all other eastbound commodities occupy little cargo space, such as silk, tea, cotton fabrics, drugs, lacquerware, art goods, toys, and firecrackers.

As a consequence of poorly balanced trade, a large portion of cargo space on eastbound liners must move in ballast, a condition leading to higher rates and heavy governmental subsidies. The tramp, not being attached to any route, can carry cargo westward and does not have to return directly to North American ports. Tramps carry most of the lumber and less than one fifth of the wood pulp shipped from the Pacific Northwest, and they find employment in the carriage of salt from California, phosphate from Florida, and occasionally other commodities. In the eastbound trade, tramps handle only occasional cargoes of Philippine sugar, copra, and hemp. As on other overseas routes, the liner now reigns supreme in the North Pacific trade and will continue to gain in importance.

Hawaiian and Alaskan traffic. The Hawaiian Islands have a place in Pacific trade much greater than their area would indicate. The Hawaiian staple is sugar, stimulated by the tariff, the crop averaging about 950,000 tons a year. Some of it now reaches our Atlantic ports by way of the Panama Canal, although most of it goes to the ports of the Pacific mainland, which are also importing bananas, pineapples, and other tropical fruits from these islands. The frequent service from San Francisco makes that city an important base of Hawaiian supply as well as a market for Hawaiian goods. Some of the Hawaiian traffic is worked in a semicircular manner similar to Caribbean traffic with western Europe via the Azores. Thus, one line routes its ships from Puget Sound to Portland, San Francisco, Honolulu, Manila, and Yokohama, the vessels returning to Puget Sound by the same path.



Flat maps deceive us much in high latitudes. Note Pacific distances.

Alaskan traffic with our West Coast includes southbound fish (salmon, halibut, cod, and herring), minerals, and furs, and northbound manufactures and military supplies. Vessels pass both from San Francisco and Seattle, although the latter, because of its nearness, has a larger trade and a route that lies largely within the shelter of the archipelagoes which skirt the shores in this region. The Alaskan ports of Juneau and Skagway are located on the mainland not far from Sitka, while Seward is the coast terminus of a railroad from Fairbanks in the heart of Alaska. The trade of Alaska, Hawaii, and Puerto Rico with continental United States, as well as trade between

our Atlantic and Pacific coasts, is restricted by law to ships flying the American flag.

7. SUEZ AND PANAMA—VITAL GATEWAYS OF COMMERCE

Effects of the Suez Canal upon trade and shipping. Man is continually seeking shortcuts as he pursues his eternal conquest of space. The completion of canals at Suez (1866) and Panama (1914) provided ocean-going vessels with shortcuts resulting in enormous savings in distance, time, and money. Suez afforded a new gateway to the Indian Ocean; Panama, a new gateway to the Pacific. Both canals have been in operation long enough for their commercial significance to be appraised clearly.[7]

The opening of the Suez Canal saved approximately 4500 nautical miles on the voyage from London and Liverpool to Bombay as compared with the Cape route, 3000 miles to Yokohama, and 1000 miles to Sydney. The shortcut to the Orient resulted in a lowering of prices of many commodities and a great increase in trade. It also served as a stimulus to the construction of larger steamships with more powerful engines, both liners and tramps. From the beginning, the canal has been of greater importance to India than to points farther east, for ships clearing from Bombay and Calcutta save more distance by using the canal than do ships sailing from Singapore, Batavia, Sydney, Hong Kong, and Yokohama. The canal has meant much more to the countries of Europe than to the United States. It has been of greater importance to the liner than to the tramp.

The liner aims at speed, and virtually all liner traffic between European ports and those of Asia and Australia is routed via Suez. The tramp seeks economy, and its routing is very sensitive to changes in freight rates. When rates are high, more tramps use the canal. When they are low, tramps avoid the canal tolls and follow the cheap route via the Cape.[8] Virtually all tramps clearing from Australian ports for Europe follow the Cape route, and those clearing from ports east of India are likely to do so if freight rates are low.

More than 12,000 vessels pass through the Suez Canal every year, over one third of which are British.[9] Huge oil shipments from the Persian Gulf have been a bonanza for the canal company in the postwar era in spite of the completion of new pipelines from Saudi Arabia to the Mediterranean. The average tanker pays about $20,000 in tolls for every round trip through Suez.[10] In 1952 tankers accounted for nearly 50% of the total net tonnage of vessels with cargo using the canal. Most of the tankers were American, British, and Norwegian.

Effects of the Panama Canal. As in the case of Suez, the opening of the Panama Canal radically changed the distance element in the applied geography of transport. For example, it saved approximately 7900 miles from New York, 8900 miles from New Orleans, and 5700 miles from Liverpool on the voyage to San Francisco by eliminating the long trip around South America through the Strait of Magellan (see Table 36:2). Eastern North America and northwestern Europe very definitely gained as a result of the opening of the canal, for they were placed much nearer by steamer route to all of western North America, western South America, and New Zealand. For eastern North America the canal has meant a great reduction in the distance to Japan and

[7] See Sargent, *op. cit.*, pp. 80–96, and Hugh J. Schoenfeld, *The Suez Canal in World Affairs,* Philosophical Library, New York, 1952.

[8] The Suez Canal company charges all that the traffic will bear. The toll amounts to $1.60 per net ton for ships laden with cargo, half this amount for ships in ballast, and $1.60 for passengers over 12 years old. Children between the ages of 5 to 12 pay half-fare.

[9] Suez Canal traffic in 1952 (million net tons): total 86.1; British, 28.6; Norwegian, 13.5; French, 7.7; Panamanian, 6.8; U. S., 6.3; Italian, 4.7; Dutch, 3.9; Liberian, 3.1; Swedish, 2.6; Danish, 2.5. Chamber of Shipping of the United Kingdom, *Annual Report, 1953–1954,* London, 1954, p. 166. *Note:* Vessels flying the Panamanian and Liberian flags are owned almost entirely by American and European firms.

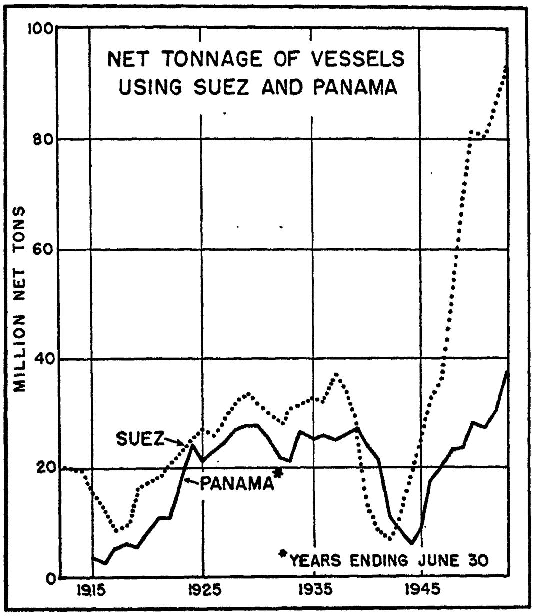
[10] Ernest O. Hauser, "Richest Ditch on Earth," *The Saturday Evening Post,* February 19, 1949, p. 116.

to all of China north of Hong Kong, a factor that has unquestionably contributed to the rapid growth of our trade with East Asia. Above all, the Panama Canal greatly stimulated trade between western and eastern United States, and it opened up an entirely new economic vista to the whole west coast of South America, virtually tying that region commercially to the east coast of the United States.

TABLE 36:2. Savings by the Panama Canal

	Nautical miles	Days at 10 knots	Days at 16 knots
Liverpool to San Francisco	5666	23.1	14.2
Liverpool to Honolulu	4403	17.8	10.9
Liverpool to Valparaiso ..	1540	5.9	3.5
Liverpool to Yokohama ..	— 694	— 2.4	— 1.3
Liverpool to Shanghai ...	— 2776	— 11.0	— 6.8
Liverpool to Sydney	— 150	— .6	— .4
Liverpool to Adelaide	— 2336	— 10.8	— 6.1
Liverpool to Wellington ..	1564	6.0	3.5
New York to San Francisco	7873	32.3	20.0
New York to Honolulu ...	6610	27.0	16.7
New York to Valparaiso .	3747	15.1	9.2
New York to Yokohama .	3768	15.2	9.3
New York to Shanghai ..	1876	7.3	4.4
New York to Sydney	3932	15.8	9.7
New York to Adelaide ...	1746	6.7	4.0
New York to Wellington .	2493	9.9	6.0
New Orleans to San Francisco	8868	36.4	22.6
New Orleans to Yokohama	5705	23.3	14.4
New Orleans to Valparaiso	4742	19.2	11.8

The Panama Canal is almost as definitely American in its function as the Suez Canal is British. In 1952 a total of 6524 vessels passed through the Panama Canal, 2084 ships flying the U. S. flag.[11] For 15 years prior to World War II, Suez and Panama handled approximately the same volume of traffic, but Suez now leads about 3 to 1 largely because of its huge oil traffic. In yet another respect the two great canals are different. The Cape of Good Hope offers important competition with Suez, while the Magellan route has very little traffic and is a sorry substitute for Panama.



Read here the record of German submarine and airplane, and of Middle East oil. ***Chamber of Shipping, United Kingdom, and U. S. Bureau of the Census***

After World War I many liner services were established via Panama. The Japanese built up liner services between eastern America and Japan, and the British developed many direct services from the United Kingdom to ports on the west coast of North and South America and to New Zealand.

Suez *versus* Panama. The long routes from Suez and Panama meet and cross in the Far East and Australasia. Ships going from Liverpool to the Far East find it shorter via Suez to points along the Asiatic coast as far north as Vladivostok and at least as far east as Sydney and Brisbane. On the other hand, ships from New York find it shorter via Panama to points along the Asiatic coast as far south as Hong Kong and as far west as Albany, Australia.

It must be remembered, however, that other factors, such as quality of goods, credit terms, prices, and tariffs, may offset the advantage

[11] Panama Canal traffic in 1952 (million net tons): total, 24.2; American, 9.2; British, 5.7; Norwegian, 2.5; Panamanian, 1.2; Honduran, 1.0; Swedish, 0.7; Danish, 0.6; French, 0.5; Japanese, 0.5; Dutch, 0.5. Chamber of Shipping of the United Kingdom, *op. cit.*, p. 167. *Note:* Ships flying the Panamanian and Honduran flags are owned almost entirely by American and European interests.

of distance. Furthermore, a matter of 500 to 600 miles on a 12,000-mile sea voyage does not materially alter freight rates, for freight rates are determined more by the amount of return cargo and the amount of way-cargo en route than by mere mileage. Hence, savings in distance should not be taken too seriously in forecasting the relative importance of Suez and Panama as gateways to this twilight zone.

The canals at war. Strategically the Suez Canal has long been of great importance to Great Britain, and the Mediterranean-Asiatic route has long been called the "lifeline of the Empire." During World War I half of all British ship losses from submarine warfare occurred in the Mediterranean Sea. The danger of attack by German submarines sent most Allied merchant vessels scurrying to the open sea route around the Cape of Good Hope.

During World War II German aircraft attacked the Suez Canal 64 times, dropping many bombs and mines. Traffic through the canal was stopped completely for 76 days. Air attacks on the canal and heavy bombing of Allied shipping from Italian islands in the Mediterranean compelled the diversion of traffic for months at a time. 1942 was a black year in Suez Canal history, for only 7 million tons of shipping passed through the canal, as compared with 34½ millions in 1938 and 93 millions in 1953. Thus, the lifeline through Suez suffered from strangulation at the hands of the enemy (see Fig. 641).

During World War I one of the major functions of the Panama Canal was to facilitate the shipments of Chilean nitrate to the United States and our allies. Unfortunately, landslides closed the canal to traffic from September 18, 1915, to April 15, 1916.

In World War II the Panama Canal played a major role, for the United States and its allies were confronted with the power of Germany in Europe and Japan in the Far East. Between July 1, 1941, and June 30, 1945, 23,008 vessels transited the canal.[12] These included 8010 ocean-going merchant vessels, 1212 small commercial vessels, and 13,786 vessels exempt from tolls, chiefly our warships. During this period more than 45 million tons of cargo were carried through the canal. The Panama Canal was unquestionably one of our greatest wartime assets. We guarded it well, and it served us well in winning a difficult war with Japan.

[12] "The 'Big Ditch' Reveals Its Secrets," *The New York Times Magazine,* November 18, 1945, p. 6.

37· The World's Airways

1. THE AIR AGE

Our shrinking world. The "last word" may never be written in the annals of man's conquest of space. At present no place in the world is more than 35 hours away! This simple, startling fact is the achievement of men who build and fly planes. It reveals how nations are shrinking to neighborhoods, how distant frontiers are losing their mystery. Mountains, oceans, deserts, jungles, and polar icefields are no longer the same barriers to transportation and trade. Travel by air is now measured in hours and minutes rather than in hundreds and thousands of miles. We are compelled, therefore, to revise many of our concepts as the world enters a new epoch, the Air Age.

Unlike those who traverse the earth's surface, the aviator is able to follow the arc of a great circle, the shortest route between any two points on the globe. In contrast with the mariner, the aviator is no respecter of coastlines. He encounters no bottlenecks, such as Malacca and Gibraltar, Suez and Panama. To him every city and town, whether it be inland or coastal, is a potential port of call. His navigable ocean is the air, a universal ocean extending to the threshold of everyman's door. Few places cannot be reached by air.

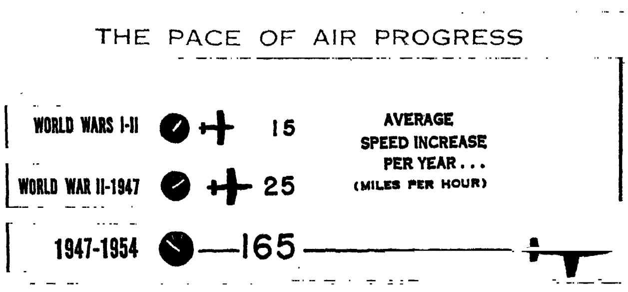
The great mail-order houses of Chicago are not yet shipping their wares regularly by air to customers all over the world, but in many remote areas the Air Age has surely arrived. In some places man has shifted suddenly from the most primitive to the most modern means of transportation. Surprising amounts of food, supplies, and mining machinery are delivered by plane to mining communities in interior Alaska and the North Woods of Canada, lands of the snowshoe, dog sled, and birch-bark canoe.

Denizens of the Amazonian forest who have never seen a wheel, have seen the airplane fly over. The Andean countries of South America are passing directly from pack trains of llamas and mules to the airplane, aerial freight including lumber, fuel, radios, refrigerators, barbed wire, heavy machinery, galvanized iron, and even cattle and sheep. Caravans of dusky porters in Darkest Africa now gaze at winged caravans in the sky. Many natives of New Guinea, Siberia, and China have never seen a locomotive, steamboat, or motor truck, but they know the cargo plane well.

The cultural impact of the airplane upon remote peoples is often tremendous. To the Eskimos of northern Canada the airplane now brings such varied articles as outboard motors, repeating rifles, sewing machines, and ladies' girdles. For good or for evil, we live in a rapidly shrinking world.[1]

We have seen that on the North Atlantic speed, comfort, and luxury in ocean travel

[1] See Wendell Willkie, *One World*, Simon & Schuster, New York, 1943, and Waldemar Kaempffert, *The Airplane and Tomorrow's World*, Public Affairs Committee, Inc., New York, 1943.



Planes Magazine, January 1955

have been developed to a supreme degree. In contrast with the tiny *Mayflower* that delivered its cargo of famous ancestors in 65 days, the luxury liners *Queen Elizabeth, Queen Mary,* and *United States* make the run from Bishop's Rock (Southampton) to Ambrose Light (New York) in a little less than 4 days.

Today the "Flying Clippers" of the Pan American World Airways make the transatlantic run regularly in 12 hours, carrying 61 passengers. Each of these luxury airliners has a maximum take-off weight of 71 tons, a payload capacity of 12½ tons, a cruising speed of about 340 miles per hour, and a cruising altitude of 15,000 to 25,000 feet, far above rough air and surface storms. Some of these clippers have made the trip from New York to London in less than 9 hours. By fastest bomber Europe is less than 4½ hours away! Death leads!

Growth of air transportation. Commercial aviation is a new and rapidly expanding industry. In 1939, only 12 years after Lindbergh's memorable flight from New York to Paris, the world was spanned by airways. Regular airline service extended from London to such distant points as Sydney, Singapore, and Capetown; from Paris to Saigon and Tananarive; from Berlin to Rio de Janeiro and Kabul; from Amsterdam to Batavia and Paramaribo; from New York to Buenos Aires, Lisbon, and London; and from San Francisco and Los Angeles to Honolulu, Auckland, Manila, and Hong Kong.

In the early 1930's most industries were bogged down in a business depression, but commercial aviation and the manufacture of aircraft continued to expand. Between 1930 and 1938 the total distance flown by the world's scheduled airlines increased at an average rate of 17% per year. In 1938 these commercial lines flew 233,756,000 miles, or more than treble the mileage of 1930 and 12 times that of 1926.[2] Only a new and aggressive industry could achieve such a meteoric rise.

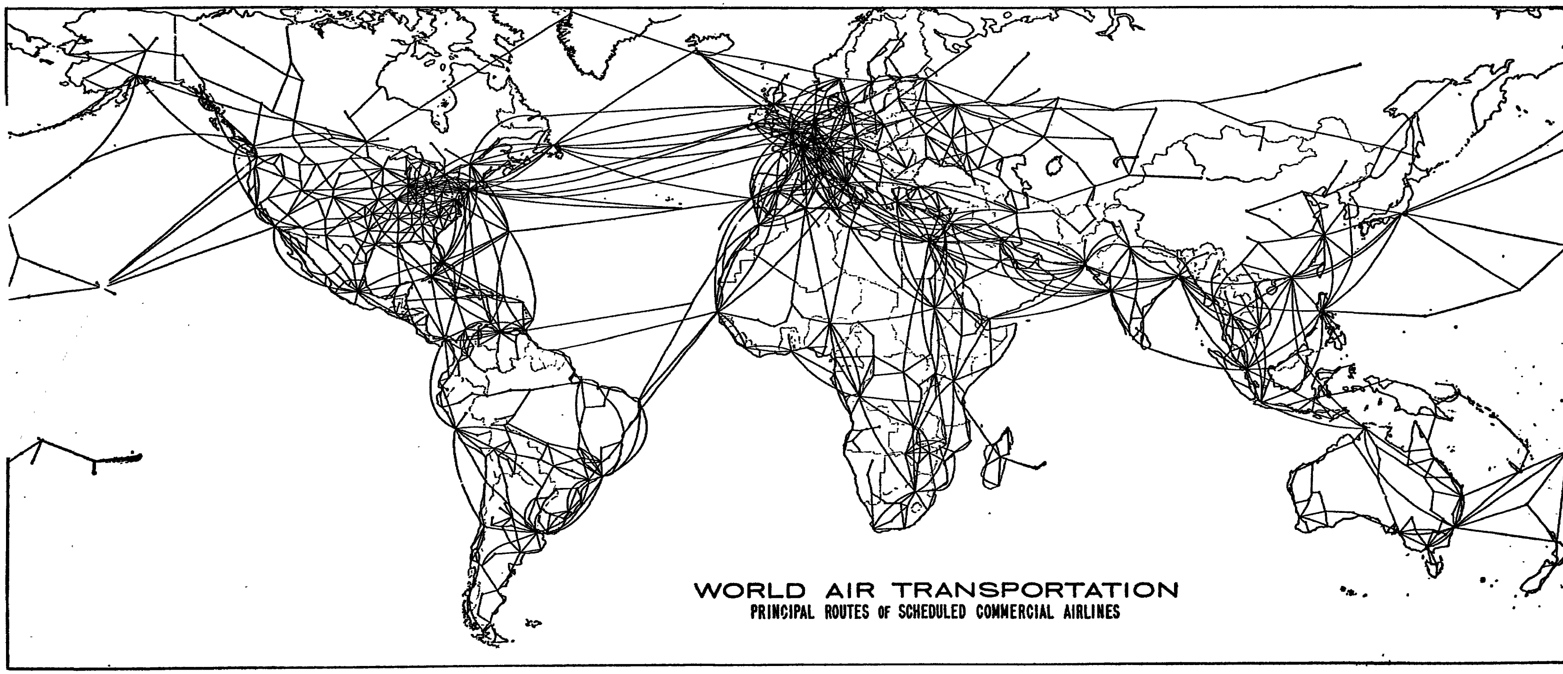
In the prewar development of air transportation the United States played a leading role. In 1938 our *domestic* airlines possessed only 10% of the route mileage of the world, but they accounted for 30% of the total miles flown.[3] They carried 1.3 million passengers, or more than the Soviet, German, British, Dutch, Australian, French, and Canadian airlines combined. The ton-mileage of mail service performed in this country was surpassed only by British airlines, which served not only the United Kingdom but also European and long Empire routes. The movement of air express or freight in the United States, however, was comparatively small, as all of it (3700 tons) could have been loaded into one railway freight train.

Between 1943 and 1953 commercial air transport in this country made great progress. The number of planes operated by our scheduled airlines increased from 204 to 1102. The revenue plane miles flown increased from 108 to nearly 510 millions. The number of revenue passengers increased from 3 to 28 millions, while the amount of air freight and express increased from 28,964 to 348,061 tons.[4] In addition to the regular service rendered by our scheduled airlines, much freight moved by chartered planes, the "tramps" of the air.

[2] Joseph B. Hubbard, "World Transport Aviation," *Harvard Business Review,* Fall 1944, pp. 510–511.

[3] *Ibid.*

[4] Transportation service performed for revenue by scheduled domestic trunk lines and local service airlines in 1953: 14,619 million passenger-miles, 72 million ton-miles of mail, 43 million ton-miles of express, and 133 million ton-miles of freight. Air Transport Association of America, *Air Transport Facts and Figures, 1954,* Washington, 1954, p. 13.



Note resemblance to the railway net maps of North America and Europe (Figs. 580 and 600). Also see duplicates of the sailors' North Atlantic trunk and Mediterranean-Asiatic trunk sea routes (Figs. 628-629). Airplane is expensive, but it beats the railway in serving the cold desert, the dry desert, and the jungle desert. Note the new Los Angeles-Greenland (Bluie West Eight)-Copenhagen route. *Adapted from G. Etzel Pearcy's map for the National Council of Geography Teachers, 1951*

Although the British have pioneered in the use of commercial jet transports, U. S. airlines have played the largest role in postwar international aviation. In 1953 United States scheduled airlines operated 563 planes on more than 210,000 miles of international and territorial routes, carrying about 34 million revenue passengers.[5] More than half of all persons who cross the North Atlantic now travel by air, and over one half of this traffic is handled by American airlines. By far the largest of our overseas airlines is the Pan American World Airways System, which operates over 60,000 miles of routes abroad. In addition, Pan American has important affiliates maintaining service on more than 84,000 miles of routes throughout Latin America.[6]

More than 250 commercial airlines now offer regular, scheduled service in different parts of the world.[7] Some are small, such as the Flugfelag Islands Airline that fans out from Reykjavik to serve the coastal settlements of Iceland. Others are gigantic in scope, such as Pan American, Trans World Airlines, the British Overseas Airway Corp., Air France, Aeroflot (Russian), Sabena (Belgian), and the Royal Netherlands Airways. In 1954 American scheduled airlines, operating domestic, territorial, and international services, provided a greater lift capacity than the rest of the world's air carriers combined.

2. AIR TECHNICS, POLITICS, AND ECONOMICS

Technological progress. Present traffic along the world's airways is a result of technological achievements of the past. From the time that the Wright Brothers' tiny flying machine tottered into the air in 1903 until the present day, inventive genius has faced the problems of building good planes and motors and surmounting the hazards of the weather. These problems now appear to be nearly solved.

During the 1930's wood gave way to metal in plane construction, and greater streamlining was achieved. More powerful and reliable engines were built, and much better fuel was used. The instrument panel became scientific, radio communication was improved, robot pilots permitted blind flying, and radio beams made blind landings safe. Well-lighted and well-marked airways and airports appeared throughout the world.

Between 1930 and 1950 the power output of airplane engines increased from about 500 h.p. to more than 12,000 h.p. The maximum speed of transport planes increased from about 125 to 375 miles per hour, while the range of flight rose from 500 to 8000 miles. During this period the weight of the plane grew from about 12 to 85 pounds per square foot of wing area, a sevenfold increase in the usefulness of the airplane as a carrier of weight.

The perfection of many inventions during World War II has greatly improved the aviator's ability to cope with the weather, his most unremitting and unpredictable foe. Among them is an anti-icing device that circulates hot air from the engine into the wings and tail surfaces, thereby preventing the formation of ice at any time. Another achievement is radar, the magic eye that guides a plane through storm or fog and gives warning of an unseen object ahead. High-altitude flight permits man to fly above the weather, especially on long-distance runs. However, even stratosphere planes are earth-bound, since upon landing and departure they must face such hazards as icy runways, sudden thunderstorms, and gusts of violent winds.

At the outbreak of World War II the most widely used commercial transport in this country was the Douglas DC-3, a 12½ ton, 21-passenger plane with a cruising speed of 195 miles per hour and a range of 1700 miles.

[5] Transportation service performed for revenue by scheduled U. S. airlines on international and territorial routes in 1953: 3439 million passenger-miles, 25 million ton-miles of mail, 76 million ton-miles of freight and express. *Ibid.*

[6] For historical accounts of Pan American, see Matthew Josephson, *Empire of the Air,* Harcourt, Brace & Co., New York, 1944, and "Clipper Skipper," *Time,* March 28, 1949, pp. 84–92.

[7] See G. Etzel Pearcy, "Air Transportation—World Coverage," *Journal of Geography,* March 1949, pp. 105–112.

During the war Boeing's Stratocruiser was used as the Army's C-97 transport, a 65-ton, 100-passenger plane with a cruising speed of 340 miles per hour and a range of 3500 miles. In 1951 the Army was using the Consolidated XC-99 transport, a 163-ton plane capable of carrying 400 troops more than 8000 miles at a speed of 350 miles per hour. In January 1954 the largest planes in commercial aviation were the DC-7, capable of carrying more than 70 passengers, and the Super Constellation that carries about 80 passengers.

So rapid has been the progress of aeronautical science within the last few years that lurid fantasy becomes accepted reality almost overnight. Nobody knows the answers to such questions as: How big? How fast? How high? How far? These technical questions are no longer important, as planes can now be designed for almost any purpose. The big questions about planes of the future are: What will they carry? Where will they go? At what cost? For present-day international aviation an even greater question is: Who owns the air?

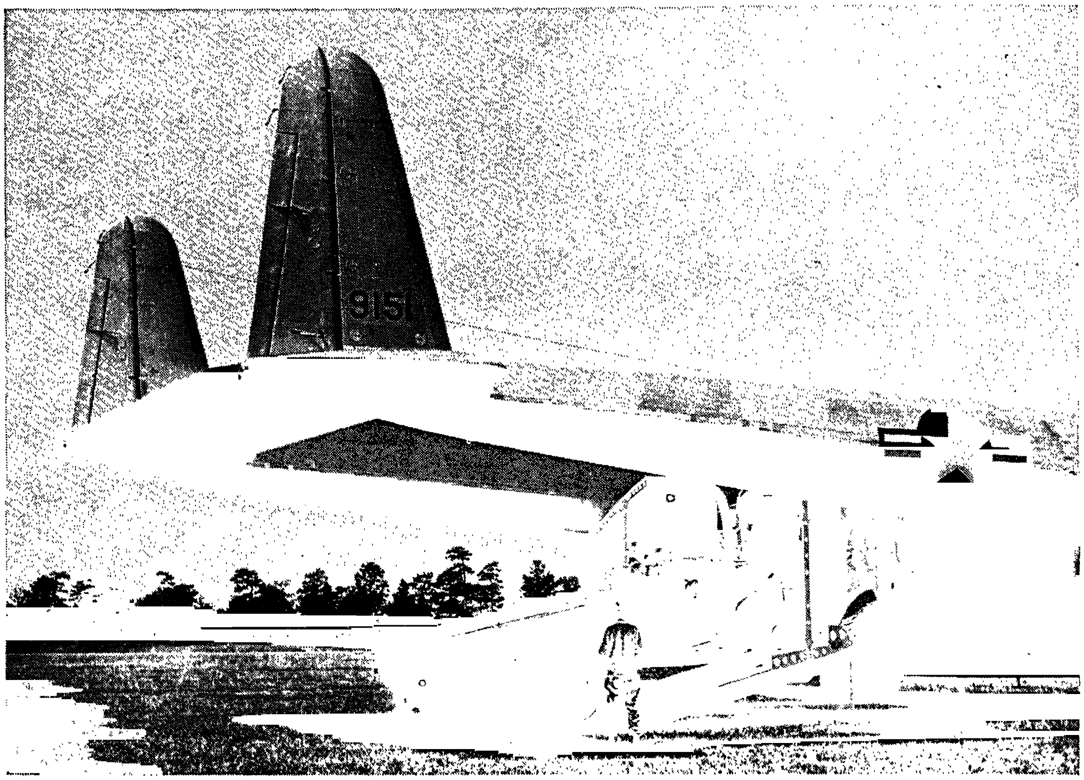
Political hazards. Technically, the world is ready for a great expansion of international aviation. Politically, it is ill prepared. Today the greatest obstacle to the growth of international air transport is the prevailing doctrine of national sovereignty, each nation stubbornly insisting that it owns the air above its territory to an indefinite height. In practice this means that foreign planes cannot land within a nation's limits unless previously granted permission by treaty, franchise, or some other arrangement.

The pioneer airmen who made around-the-world flights were forced to seek the aid of their governments in obtaining rights of passage from every country that they intended to cross. The establishment of commercial air routes across international boundaries was preceded in almost every case by hard-fisted bargaining and often by prolonged diplomatic disputes. "An eye for an eye, and a tooth for a tooth" was (and still is) the order of the day. A few examples may be cited.

In the prewar era Turkey closed its skies to all foreign planes. German airlines, except for a few experimental flights, were excluded from North America, and for some years they were kept out of France. Spain admitted German and Italian airlines but barred the British, French, and Dutch. For a time Great Britain blocked a French air route to Indochina, although it gave the Dutch flying rights over India in return for the privilege of an air route to Australia via the Netherlands East Indies. A few tiny countries, because of strategic locations, forced foreign airlines to pay exorbitant fees for landing rights and also to provide lucrative jobs for the local citizenry.

All nations joined the cut-throat game of aeropolitics. The United States closed the air of Hawaii to all foreign planes, thus making prewar transpacific flying an American monopoly. In retaliation, Australia denied entry to our Pan American World Airways. In 1936 this American line was admitted to British Hong Kong only after it had acquired landing rights in Portuguese Macao about 70 miles away. In 1935 Pan American was ready to cross the North Atlantic but was not allowed to enter Great Britain until 1939, after it had obtained landing privileges in the Azores, Portugal, France, and Eire. In December 1945 Pan American cut its New York-to-London passenger fare from $572 to $275, and the British, fearful of competition, immediately restricted Pan American flights to two a week instead of five.

In postwar years the United States government has made agreements with Great Britain, France, and a number of other countries regarding the use of the air. For example, at a conference in Bermuda in 1946 the United States accepted the principle of rate control in exchange for British acceptance of no control over frequency or capacity of service. We granted the British full traffic rights at 11 cities in continental United States and at six points in our territories, including Hawaii. The British allowed us traffic rights at 18 points throughout the Empire. Disputes between airlines are now referred to an im-



This 11,000-pound truck crawling into a plane tells us of the rising air freight traffic. ***Fairchild Aircraft, Hagerstown, Md.***

partial referee. Rates and schedules for international routes are determined by traffic conferences established by the International Transport Association, a private organization of international airlines. All traffic conference agreements are subject to the approval of the respective governments.

Bilateral agreements, such as the one achieved in Bermuda, represent progress toward freer use of the air. However, for those who are unable to bargain successfully, "freedom of the air" remains an empty phrase. As yet the air policy of every nation is a mixture of commercial and military expediency. National governments are well aware that the airplane is a terrible instrument of warfare as well as a vehicle of commerce. In the Air Age of today we are all neighbors—that is, we are near enough to be—but in an era of atomic bombs and instantaneous destruction we are potentially neighbors-in-hell.

Petty nationalism remains the greatest liability of the twentieth century. Those who believe in international cooperation are agreed that there must be more yielding of sovereign rights, more merging of national powers, more willingness to accept the decrees of a World Air Administration—if the peoples of the world are to reap the full benefits of modern aviation and still preserve the peace.[8]

Economic obstacles. The chief disadvantage of the airplane is that it is a poor carrier of weight. Seldom does the revenue load amount to 25% of the total loaded weight of the plane. Some things are simply too heavy, too bulky, and too low in value to be handled by airplanes. Not even aviation's most ardent enthusiasts predict that grain, coal, cotton,

[8] See Keith Hutchison, *Freedom of the Air,* Public Affairs Committee, Inc., New York, 1944; Adolph A. Berle, Jr., "Freedoms of the Air," *Harper's Magazine,* March 1945, pp. 327–334; and R. R. Hackford, "Our International Aviation Policy," *Harvard Business Review,* Fall 1947, pp. 483–500.

timber, iron ore, and similar commodities will move in appreciable quantities by air.

Only in regions where modern transport facilities are lacking or where competitive freight rates are high, as in the Andean countries, northern Canada, and tropical forest areas, does the airplane become a truly economical carrier of machinery and other items of heavy freight.

Occasionally some very heavy objects are moved by airplanes. For example, in 1951 a scheduled airline plane hauled a 32½-foot, 11-ton tie rod for an extrusion press from Philadelphia to Los Angeles, the heaviest single piece of machinery ever carried by air.[9] However, the great bulk of the world's air traffic consists of passengers, mail, and express. These compact, high-valued cargoes can afford the cost of high speed. The limitation of the airplane as a carrier of weight is shown by the fact that in 1953 scheduled trunk airlines in the United States obtained 88½% of their total operating revenue from passenger traffic, about 4% from carrying the mail, 2½% from excess baggage and minor services, and only 5% from freight and express. In 1953 the average weight of airfreight shipments was less than 150 pounds.

During the war the Army's Air Transport Command operated the world's longest freight line, spanning the globe in 116 hours of actual flying time.[10] The ATC moved vast quantities of supplies over long distances at high speed but with *no* regard for cost. The commercial air transport company must have a high regard for expense.

Speed and frequency of service are the airplane's two prime assets. Hence, the handicap of a small unit load may be partially offset by fast and numerous trips, and an airline may render a remarkable amount of transportation service during the course of a year. Erelong airplanes carrying 150 passengers or 40 to 50 tons of cargo will be used on transoceanic flights, but the bulk of the world's air traffic will be handled by smaller planes making frequent trips.

Each year we travel farther, faster, and more cheaply by air, and the same tendency is true in the movement of air express and freight. Nobody can predict the volume of international air traffic during the coming decade. The answer depends upon politics as well as economics. The skies of the Soviet Union and her European satellites and the skies of China are closed to foreign airplanes. Will the the world's statesmen be able to achieve freedom of the air?

3. AIRWAYS OF THE FUTURE

Great-circle routes *versus* detours. Opposed to the geographical truism that the arc of a great circle is the shortest distance between any two points on the globe is one hard economic fact, namely, that "the longer way around may be the most profitable way out." In the air, as on land and sea, transportation agencies tend to avoid "traffic deserts" almost as nature abhors a vacuum. Hence, the detour is often preferred to the direct route.

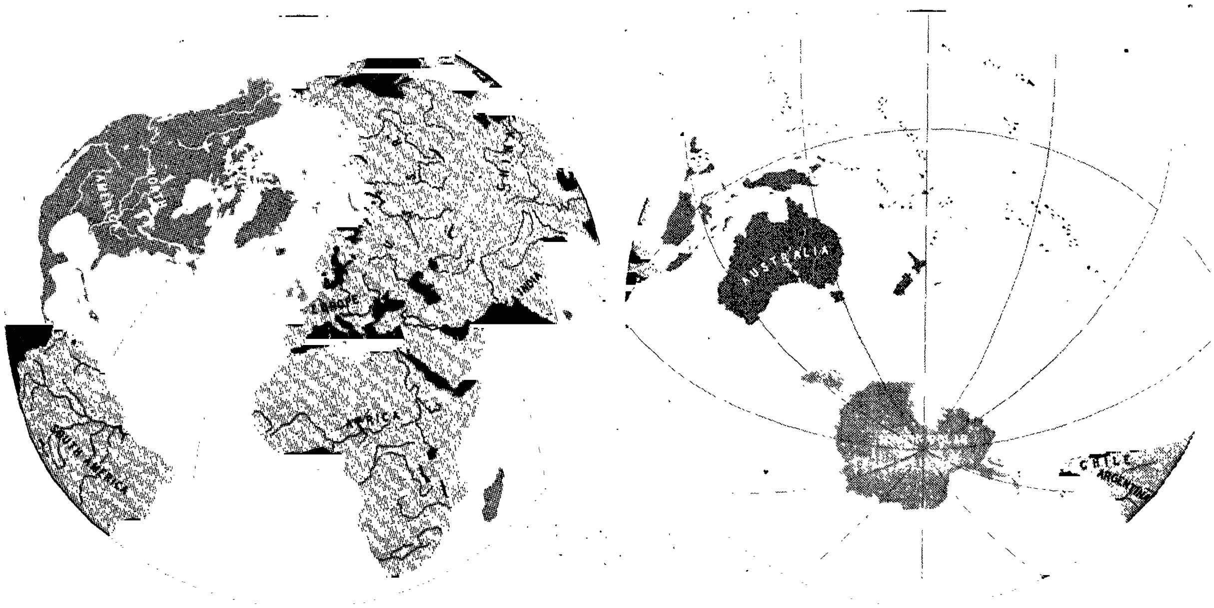
At the present time commercial aircraft do not ordinarily fly great-circle courses. Rather, they fly from airport to airport along airways serving traffic-producing and consuming areas. Prior to the war, when planes were smaller and weaker, the great oceans were usually crossed by circuitous hopping from mainland to island to island to mainland. Today our huge commercial transport planes can make 4000-mile nonstop flights with ease.[11] With the development of long-distance stratosphere flights, great-circle routes will play an increasing role.

The world is now spanned by a vast network of airways (see Fig. 645). Some of these follow great circles rather closely, while

[9] Aircraft Industries Association of America, *Planes*, July 1951, p. 2.

[10] See "The World's Greatest Airline," *Fortune*, August 1945, pp. 159–164 ff., and "The New Air Age," *The New York Times Magazine*, November 4, 1945, pp. 6–7.

[11] On trips up to 5 hours the human animal is content to sit still. Between 5 and 10 hours he must have space to go to bed. From 10 to 20 hours he must have freedom to roam. Hence, on long nonstop flights big planes are needed to provide creature comfort and also to carry a big fuel load.



A land hemisphere and a water hemisphere. No wonder New Zealanders speak of "down under" in a waste of waters. ***J. Parker Van Zandt, The Geography of World Air Transport, Brookings Institution, Washington, 1944***

others do not. If political obstacles to international aviation can be removed or alleviated, some of these airways will emerge as great trunk lines of commerce. Other routes will be no more than "country roads" of the air. Fundamentally, the importance of each air route will be determined by the interplay of five factors: (1) potential traffic between terminals and along the route, (2) the length of the route, (3) the longest unavoidable nonstop flight, (4) the availability of airports and other facilities, and (5) weather conditions.[12] Of these, the traffic factor will be dominant.

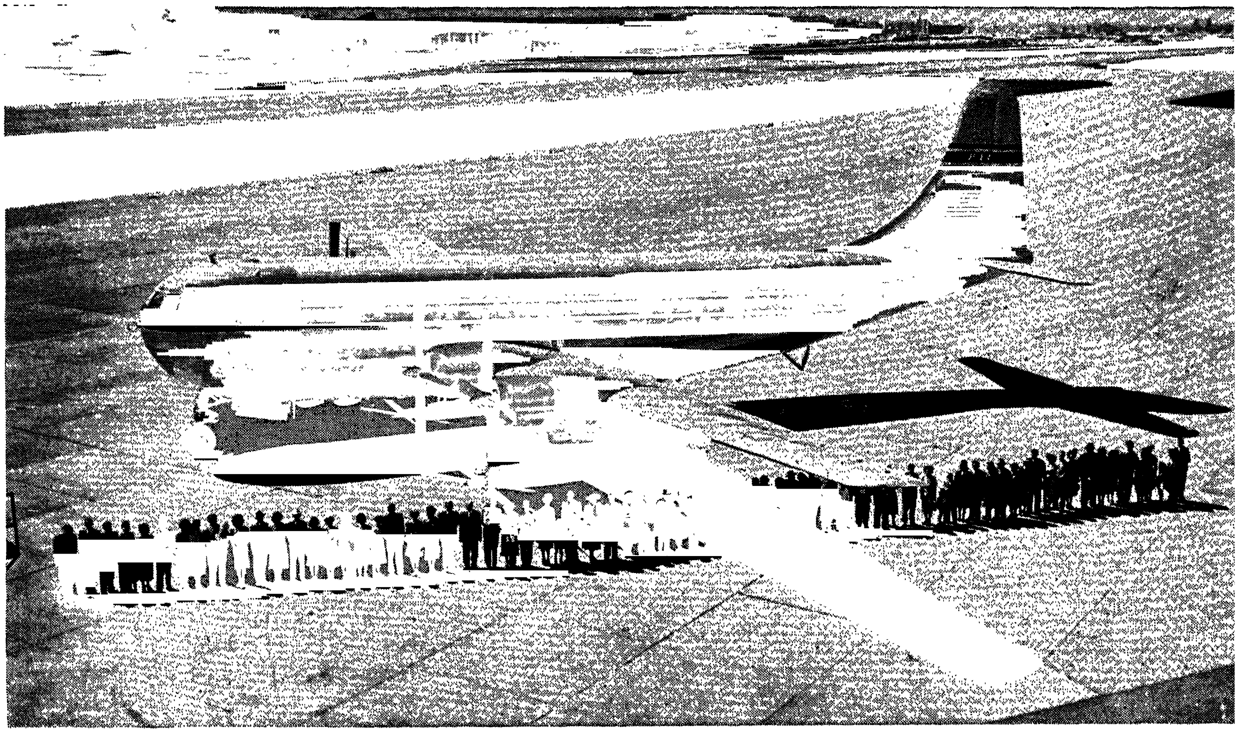
The importance of traffic as a location factor may be shown by a single illustration. The transpacific airway between San Francisco and Manila via Hawaii, Midway, Wake, and Guam is 8000 miles long. The great-circle distance is 6965 miles, but to follow the circle would involve a nonstop flight over the open sea for almost the entire distance, passing 1650 miles north of Honolulu and about 700 miles south of the Aleutian Islands. A third and more practical route avoids the watery desert and extends northward through Portland, Seattle, and western Canada into Alaska and Siberia and southward through China to the Philippines. This overland route from San Francisco to Manila is 245 miles shorter than the island route and 790 miles longer than the great circle, but its traffic potentialities are far greater. Air traffic, like that of the sea, will be *around* the North Pacific, not across it. (See a globe. All flat maps tell lies, because they lie flat!)

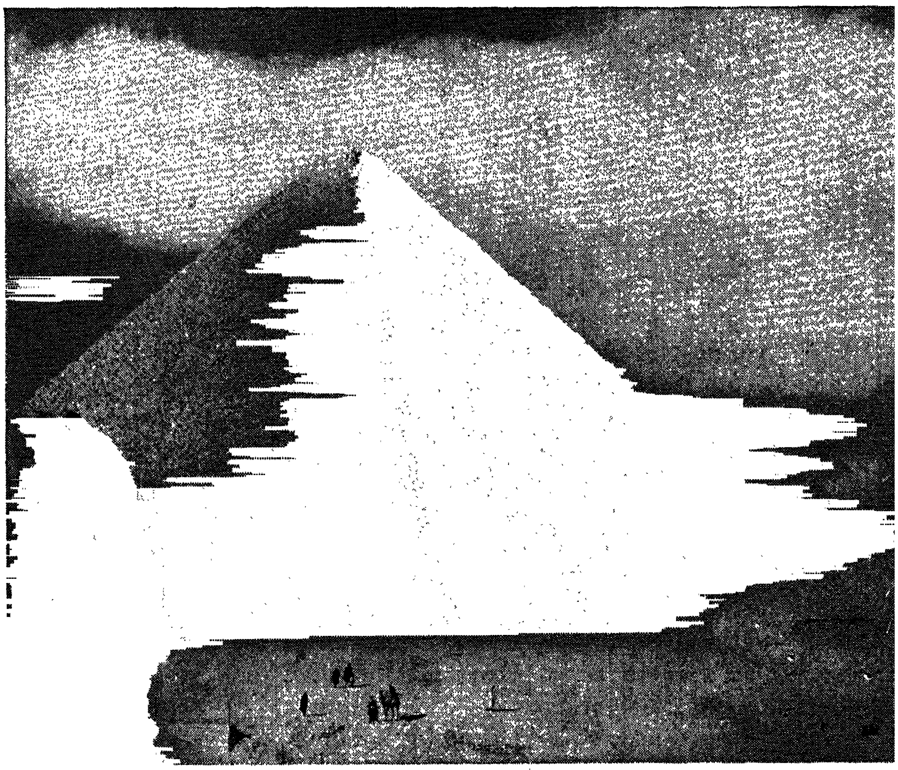
The hemisphere that matters. The earth is round, but the fact is that we live in a very lopsided world. One half of the world, known as the "land hemisphere," contains nearly nine tenths of the world's ice-free land and a preponderant share of the world's natural resources, technical skill, and financial power.[13] Here are concentrated 94% of the world's people and 98% of all industry[14] (see Fig. 650).

[12] See J. Parker Van Zandt, *The Geography of World Air Transport,* The Brookings Institution, Washington, 1944, p. 22.

[13] The precise center of the hemisphere containing the maximum amount of land is southeast of Nantes, in western France. (For a map of the world with London as the center, see Fig. 571.)

[14] Van Zandt, *op. cit.,* p. 4.





Two of the most astounding things man has made. Airplane, with its passengers lined up on the runway. The pyramids about 4900 years ago. What gadgets will we be fashioning 4900 years hence, and what resources will we have left on hand 4900 years hence? *Pan American World Airways* and *Hamilton Wright Co.*

Within the land hemisphere (see Fig. 650) are to be found four trading areas of utmost importance: (1) Greater Europe, including North Africa and Asia Minor, (2) North America, north of the Rio Grande, (3) Soviet Russia, and (4) nearly all of the remainder of continental Asia. The extent to which these trading areas dominate the world's economy is amazing. These four zones possess 59% of the world's land area and 88% of the people. They account for 81% of the total railway mileage, 85% of the cultivated land, 91% of the total earned income, 92% of all cities of over 100,000 population, 94% of the automobiles, and 95% of the factory output.[15] It is reasonable to conclude that airways on and between the Eurasian and North American continents will carry the bulk of all air traffic in the future.

The position of the United States. By geographical accident France, Great Britain, Holland, Belgium, and Germany cluster about the center of the world's land hemisphere. They have the advantage of the shortest air routes to most of the world's land. Western North America, most of South America, South Africa, and the eastern and southern Asiatic mainland lie near the periphery of the land hemisphere. Beyond the periphery are New Zealand, Australia, the Philippines, Indonesia, and southern South America. Those countries far from the center of the hemisphere will have to fly their passengers and cargoes farther, on the average, to foreign markets than those located near the center. As far as the element of distance is concerned, the position of the United States is less favorable than that of northwestern Europe.

The distance factor is of considerable importance, since the operating costs of airlines vary more directly with distance than those of railroads and ocean shipping companies. Distance, however, is only one factor in the equation of trade. Above all, the kind, the volume, and the direction of trade depend upon the productivity and purchasing power of peoples—the availability of resources per capita.

We have seen that the greatest of all overseas trade routes is the North Atlantic route, connecting northwestern Europe and northeastern United States. In these areas is the world's densest network of airlines, natural feeders for the transoceanic air traffic between them. Here are the countries most active in long-distance air transport. Across this relatively short stretch of water moves the world's greatest volume of "quality" traffic upon which air lines depend—people in a hurry, mail, and commodities of high value and little bulk. The North Atlantic will continue to be the greatest trunk-line route of the air and, like its oceanic counterpart, its termini will remain the focal points for air traffic from the far-off corners of the world. The United States will be a major participant in this trade.

A glance at the political map of the world reveals how poor the United States is as an owner of air bases for a globe-encircling merchant marine of the air. With world-wide flying ambitions, our possessions and territories offer little in contrast with the far-flung British Empire and the vast Soviet domain. Indeed, we are poor in comparison with the French, Dutch, and Portuguese—inheritors of empire.

On the vital great-circle routes leading to the north, we must petition for landing rights from the Canadians, Russians, and Chinese. Perhaps the most strategic territories lying athwart the world's network of airways are Labrador, Alaska, and eastern Siberia. In the modern era of long-distance flights no nation has a monopoly on international air routes. Alternative routes, often less desirable but nevertheless feasible, exist between all major trading zones of the world. Strategic locations can be by-passed if necessary.

Will the United Nations unite to make air commerce as free as that of the sea? Will geography and economics be slaves to sordid politics or handmaidens to a constructive statesmanship?

[15] *Ibid.*, p. 21.

38· Retrospect and Prospect

You bet your life. We are talking to the readers of this book, mostly American college students not far from 20 years of age. Many of you have 50 years to work and observe the passing scene. You are about to bet with Fate. You will bet your life that this or that area, town, corporation, occupation, profession, or specialty is so promising that you plan to spend your working life in or with it.

The Scientific Revolution. You have spent your life, thus far, during a part of the Scientific Revolution—a time in which man is acquiring new knowledge with great speed in many fields. In each it runs a cycle—new knowledge, new theory, new understanding. Then come new techniques, devices, by which the new knowledge affects industries, persons, peoples, nations, civilizations.

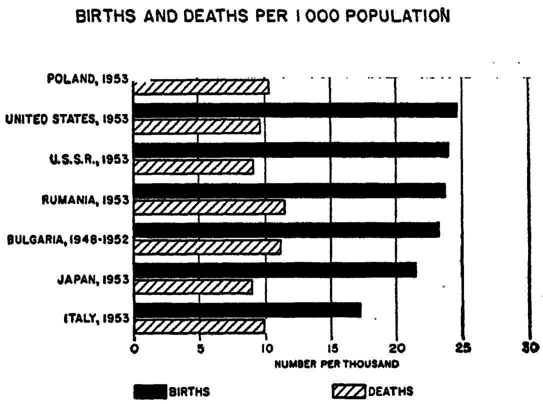
You, the American reader, have seen parts of three phases of the Scientific Revolution—(1) sanitation, (2) industry, (3) communication, and you will live with all three for the rest of your days.

1. THE SANITARY AND HEALTH REVOLUTION IMPROVES HEALTH, INCREASES POPULATION, CREATES WORLD POPULATION PROBLEMS

The Sanitary Revolution really began less than 100 years ago when Louis Pasteur, a Frenchman, discovered the existence of micro-organisms that we commonly call germs and which are the final cause of many diseases. One by one we have discovered the germs that cause particular diseases. Then we learned their life histories, how they injured us or killed us and how we could kill or avoid them.

Where infants once died like flies, the new knowledge has caused sharp decline in infant death rate. Many more now grow up, have children and grandchildren. Persons born in 1900 had a life expectancy of 46.3 years. For those born in 1951, it was 65.9 years. Fig. 653. The increase of world population is becoming explosive in its speed. In the United States and some other developed countries with plenty of land, the Industrial Revolution has gone along with the Sanitary Revolution and fed the increasing population fairly well. It is the people of the underdeveloped countries who are hungry.

The sanitary-medical revolution and world population. A biologist has made the



Rates that cannot continue. Look at this again as you finish this chapter. ***Population Index, October 1954***

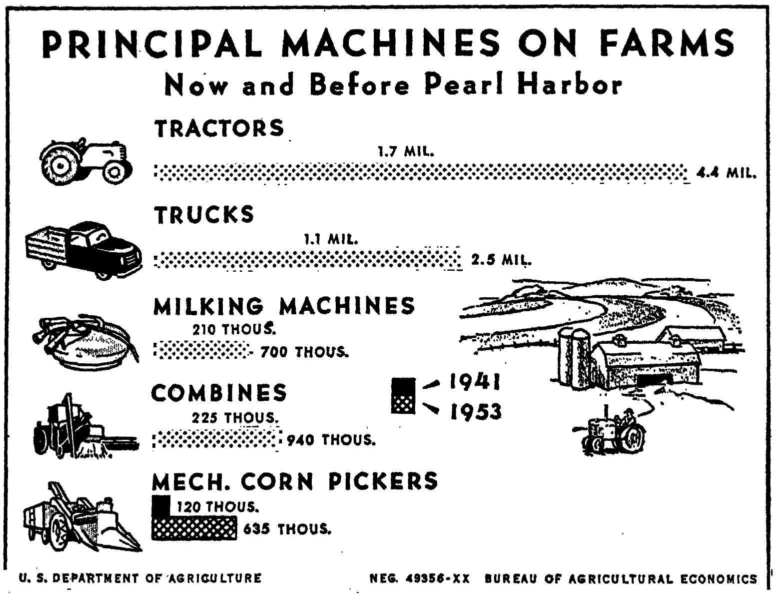
unpleasant statement that every organism increases up to the limits of the available food supply. The findings of the U. N. and other world surveys seem to agree that most of the human race is no exception, and that many countries have already passed below the level of sufficient food, if we measure by standards of nutrition that produce optimum health and energy. Are the American people exempt from this biologist's generalizations? When the senior author of this book was a schoolboy, the official population of the U. S. was 50 million. When his grandson started to school the population was 150 million. Will grandson see it rise to 450 million?

And in another lifespan after him will it be 1350 million? Plainly not,[1] but there was a marked increase of population 1940–55 because jobs were plentiful. Any healthy young high-school graduate, who was willing to work, could have an income sufficient to marry and support a family on his purchasable share of the national food supply. The depression of the 1930's had cut off city income and food supply and reduced the U. S. marriage rate and the birth rate. This scarcity produced by a man factor combines with geographic factors to swell or check the world industries we are studying. A general economic depression ranks with the major calamities or forces of nature.

2. THE INDUSTRIAL REVOLUTION. A MULTITUDE OF NEW DEVICES, MACHINES, AND METHODS CHANGE MAN'S RELATION TO THE EARTH IN MANY WAYS

Historians differ as to the beginning date of the Industrial Revolution, but look at the last 50 years, 1905–1955. During that part of the lifetime of members of your family, we have invented or discovered or introduced on a grand scale:

1. passenger automobile and motor truck
2. tractor
3. airplane
4. Diesel engine and oil-driven ship, train, truck, and tractor
5. radio
6. radar
7. science of genetics

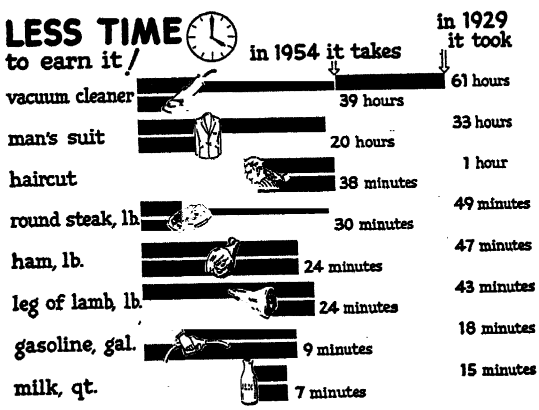


Suddenly Uncle Sam guaranteed good price, farmer bought machines, product increased, farm labor went to city.

[1] In the U. S., as in other countries, there must some day be a choice between (a) balance of births and deaths or (b) periodic reduction through famine, epidemics, and war. So says Dudley Kirk, of the Population Council, and he thinks that many countries may reach that period of hard decision in 2 or 3 generations. See *Science Newsletter*, Jan. 7, 1955. It is strange that he omitted tuberculosis and other diseases encouraged by malnutrition. Perhaps he includes them in famine. See our account of Egyptian food, page 70.

Research, a result. Sectionalized automation, also called transfer-matic. This machine, 350 feet long, has 5 removable sections. One operator, not a skilled mechanic, "puts a V-8 cylinder block into one end. . . . From there on, the machine takes over. It moves the blocks along its 350-foot length . . . clamps them firmly into position . . . performs 555 different machining operations . . . inspects them—all automatically and at the rate of 100 pieces per hour." The revolution continues, and auto workers wonder about their jobs. *The Cross Company, Detroit*

8. synthetic fibers
9. synthetic rubber
10. plastics
11. winning of metal and chemical from sea water
12. high-speed steel—the mother of the assembly line and the real creator of the Age of Machinery
13. the assembly line and vast increase of automatic mechanism (automation)
14. the electronic calculator and thinking machine

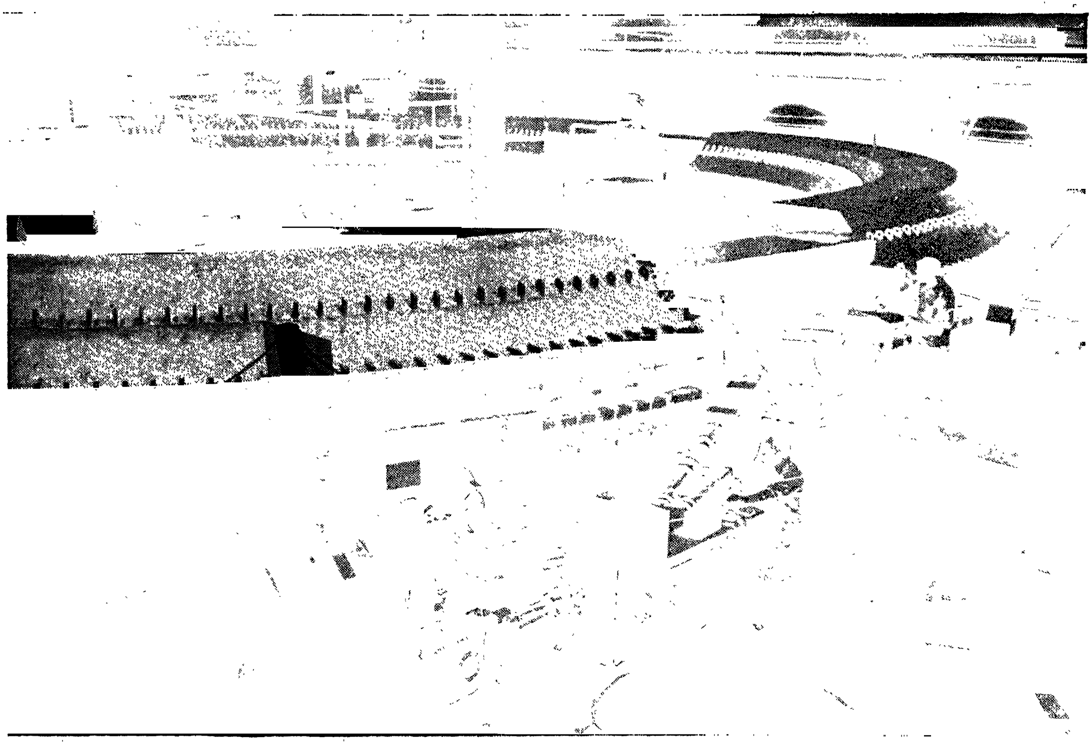


See what machinery has done. It came later to farm than town. *U. S. government figures compiled by American Meat Institute*

That is a stupendous list for one lifetime to witness, and many other inventions are just around the corner proving themselves experimentally, but they are not yet included in this above-mentioned list. It is science that has brought us to the threshold of this new and pregnant age—pregnant, but what will the offspring be? If good, it may be very, very good, but look at World War II and the atomic bomb, and imagine what would have resulted if Hitler had got it first, or Stalin.

(a) The Speed of the Industrial Revolution Is Increasing, Promises More Devices, More Wealth

Mechanical power and machines and their work have been presented, industry by industry, in our other chapters, but we wish to repeat a dictum of the late Thomas A. Edison, "Give us an order large enough, and we will make automatic machines to turn out the product." Edison's dictum is now being proved in hundreds of factories, where more and more products are being transferred from the special machine with its individual tender to the standardized automatic machine that is fed from a hopper and works in connection with moving belts, assembly line, and *inspectors,* not machinists. In 1954 a word, new to cur-



A bit of equipment for atomic research. Cosmotron at Brookhaven National Laboratory, Upton, N. Y. The "doughnut" consists of 288 flat steel blocks, 8 feet wide, 6 feet high, covered with white plastic. Forty million watts of electric energy make 3 million trips around the white circle in a second. This to illustrate the concept—research, process. *Atomic Energy Commission*

rent affairs, blossomed in business advertisements—*automation.* Fig. 655. Perhaps the Industrial Revolution is but begun. A glance at the new things of the last decade gives strong support to the idea.

(b) Research Is Speeding Up and Producing Entirely New Things

Most of the big 14 producers of Industrial Revolution listed above were the result of research in laboratories and experimental shops of the university, the textile maker, the chemical manufacturer, and the auto and other machine builders. But when Hitler menaced our freedom and our national existence, we got in a hurry. We drafted 2 billion government dollars and the top scientists of the universities; and we turned out the atomic bomb —quick.

You would be astonished if you knew how many university and other laboratories are working today on research assignments from the U. S. government.

Many large companies are increasing their research equipment. There are several research institutions that do custom work. They study problems and make experiments on request for a fee just as a lawyer does. What is the strange-looking clay in that hillside good for? A ceramics laboratory is ready to test it. Does that device of yours really improve an engine? We saw an engine doing a 6-month run in a research laboratory to answer such a question. A possible purchaser will accept the report of the laboratory at a higher valuation than he would give to the enthusiasm of the inventor. The laboratory has to maintain a reputation for reliability or quit.

New research and the continuing revolution. Do not get any hasty notion that the Industrial Revolution is completed. We have probably passed beyond the days when an English preacher or a Yankee schoolteacher can dash off such earth shakers as textile machine and cotton gin, but research appears to be just getting under way. Keep your eye on

the men with the new microscope, the test tube, nuclear physics (whatever that may be), new mathematical calculators, and money, millions of money.

Look at a picture of the Wrights' first airplane of 1903 and then at the pictures of the modern monsters you see almost every day. The transformation of the airplane is a type of the speedy evolution of machines from simple beginnings to almost unbelievable ends. What do you find now as you go through the textile mill, the machine shop, the chemical works, the wheat field, the dairy barn, the bakery? Everywhere you find transformation, transformation, transformation of equipment. You find bigger, stronger equipment is doing things that were never done before or doing the old things many times faster.

Chemistry joins the procession. In recent decades chemistry has stepped forward as industrial partner of the standardized machine; we now have mass production of chemicals. The medieval alchemist strove to transmute common things into gold, but the present-day chemist does things that would be perhaps more astounding to the medieval alchemist and certainly are more productive of economic benefit to man. Just think of beautiful fabrics from petroleum or wood pulp, nitrogen from the air to feed chemical works or plants, and thus ourselves and our beasts.

(c) More Profound Revolutions May Be in Sight

A veritable horde of persons with special training labors to put atomic energy at work in your power plant, but ex-president Conant of Harvard says he thinks power from the rays of the sun will win out.

The solar engine. Within a year two significant new devices for harnessing the sun's radiant energy have been reported. The solar engine to make power from desert sunshine, to desalt sea water, and then pump it up to irrigate the desert where food may be grown, to feed a factory town whose industries run by more desert sunshine power! ? The value of desert frontage may rise. And there is much desert and desert frontage.

Power from the sea. The heat differential between sea water half a mile down (about 40°F) and tropic ocean currents at the surface (75–80°F) is alluring, vast, and permanent. It has operated experimental engines.

Desalting of sea water has been achieved by passing sea water through a film made of petroleum and coal-tar products. At last report it requires 20 kilowatt hours of electric energy to purify 1000 gallons of sea water, and the apparatus has no moving parts.

The micro-biologist says that we can soon be eating algae, especially chlorella, rich in protein but also having almost everything else

Research. Result—molten brass pours into glass cup, toughest glass known, sitting on ice. Cup takes it. Dark object is brass solidified in cup. Every element has been used in making glass—50,000 formulas. Glass is entering astonishing new uses. *Corning Glass Works*

necessary to nourish the human body. Put some of these one-celled organisms in fertilized water, and they absorb their nourishment somewhat as a dried prune absorbs water. You put 100 little chlorellas in your test tube in the morning, and set it in the sunshine. They absorb, swell, and break in two, and by evening you may have 200 chlorellas, just like that, so say the chlorella pioneers. In this age of science who is now our leading alchemist? But hold—even chlorella must eat. A chlorella factory must be built, and then most people will have to buy chlorella. How shall we pay for it? There will be a problem of distribution. We have piles of wheat, but the hungry Pakistanee cannot buy it. Science has the nasty habit of wrapping up a problem in the package with almost every new discovery or machine.

It is anybody's guess as to what new machines, structures, gadgets, fabrics, foods, powers may be at your disposal 10—20—40 years from now. The germs of economic revolution are incubating.

In listing these possible revolutionizers we recognize them, but have no dates in mind. It takes years of work to harness these new wild horses of science. Hero of Alexandria (Egypt) reported a steam engine, 130 B.C. It was a jet engine if you please. It ran, ran nowhere, and did nothing, but it *ran*. Just the other day, 2075 years after Hero, our researchers made Hero's jet engine drive an airplane at speed greater than sound.

(d) Automation and Thinking Machines Promise Wonders within a Decade

The years in which your career will be getting started promise to see an almost bewildering use of *automation*. Look at Fig. 655. It is not a prophecy. It is an achievement. It is here. A C.I.O. official fears that it may quickly replace hundreds of thousands of automobile workers. "Automation may be likened to a combination of Watt's steam engine and Ford's famous assembly line."

"The feedback principle underlying automation and the servomechanisms required to implement it make possible the substitution of mechanical or electronic control for human control."

Control is the new word. Machines do the work, and *the machines control themselves*. These mechanical brains are able to direct such diverse operations as switching freight cars in railroad yards . . . calculating tax bills . . . taking department-store inventories . . . translating Russian into English. They can memorize and recall; they can count, compute, calculate, sort, measure, and give orders like "start" or "stop," "up" or "down," "right" or "left," "forward" or "back." They can make decisions like "too hot" or "not hot enough," "empty" or "full," "too fast" or "too slow," or any other choice that does not involve more than two alternatives.

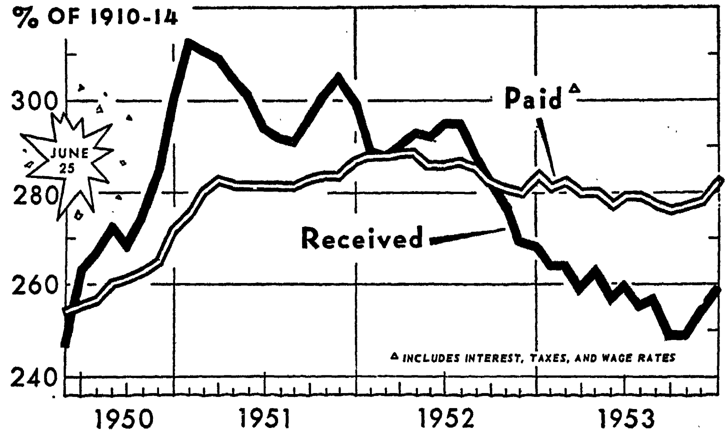
"Foric, a mechanical employee of the United States Census Bureau, reads forms submitted by census takers, picks out the right information from corresponding columns, adds five million answers in a half hour, and files it all away in a microfilm library." (The above quotations from *Saturday Review*, Jan. 22, 1955, pp. 20, 40.)

We must take our eye away from this knothole in the fence that hides the future. Let us look at the present. A few will build the future, but most of us must operate the present and use the devices that work now and realize that they may soon be superseded.

(e) The Industrial Revolution Has Produced U. S. Surplus Food and, to Some Extent, Factory Equipment and Operatives

Consider the present powers of U. S. industry. After wallowing for years with few jobs and low hope in a land burgeoning with resources in the hungry and miserable depression of the 1930's, we rose up and fought World War II. We put millions into the armies, on land, sea, air, and under the sea. We put other millions to work making the 700,000 items (actual number reported) needed to land an army on the coast of Normandy and supplied it with 450,000 gallons of gasoline a day to carry it

Prices paid and received by American farmers. The guaranteed price produced surplus. Some prices declined; town prices on farmers' supply stayed up. There is the farm problem. *U. S. Department of Agriculture*



across France. This was amazing, but even more amazing is the fact that American wages rose, doubled, trebled, quadrupled, some even more than that, during the war. Millions had more money than ever before and—here is the real shock—despite the millions of fighters and the millions who supplied them, we increased the national output of almost all kinds of consumption goods except dwellings. Radios, refrigerators, and other gadgets increased. We ate more meat and ice cream per capita. And, most astounding of all, *we did it while waging and supplying the war.* Our powers of production are dangerous unless we learn to distribute produce better. And there comes automation to pile up more stuff if we don't watch out.

Surplus and relief. In December 1954 a man we had known for years came to us for a bit of aid in getting unemployment relief. He is a sober, strong, industrious, skillful worker, but the locomotive works had no more orders, and with hundreds of others he had been laid off for four months. During this period an official of C.I.O. announced that in a short period American unemployed had missed $20 billion that they would have earned if their jobs had held.

The facts about the war and the increase of consumption level during the war make it plain, absolutely plain, that we are equipped to make more food and more factory goods than we can consume at present levels of consumption and methods of distribution.

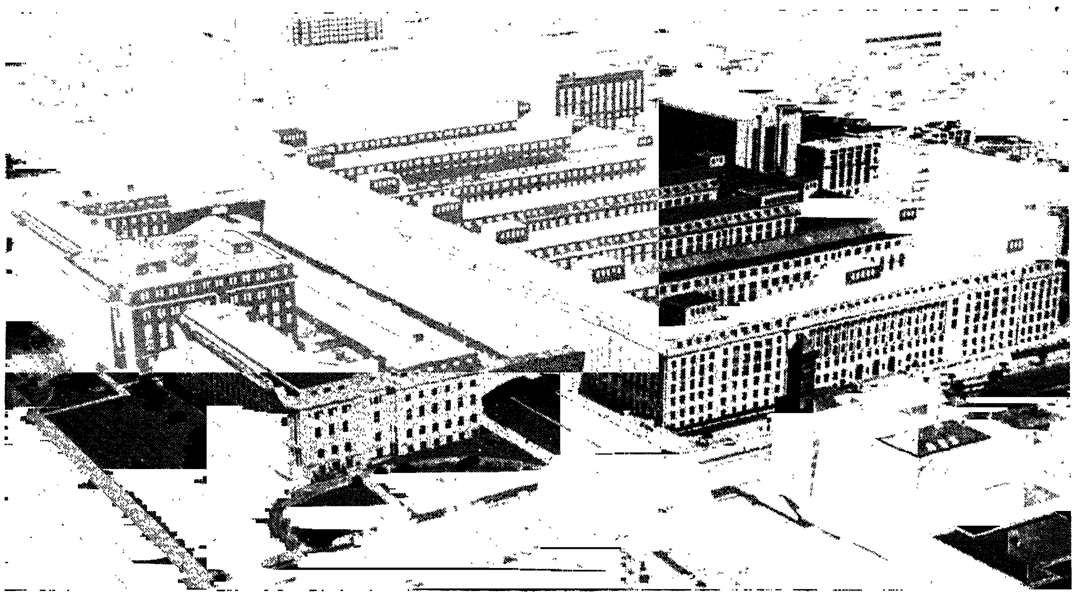
Abundance, the devil of the Machine Age, is one of its major problems. For the factory, not quite enough orders. For the factory operative, unemployment relief. For the farmer, glutted markets and the collapse to the low subsistence level unless prices are artificially held *as other* prices are. This was explained in Chapter 4, parts 8, 9 and 10.

At present, February 1955, the politicians of both parties are afraid to face the problem. They put it off by borrowing money to buy, buy, buy—building the avalanche.

(f) Our Wealth Drives Us toward Economic Isolation—That Is, Buying Less Rather than More of Manufactures Abroad. We Do This by Way of Tariffs and Price Supports

Many signs indicate that we have already moved far in this direction—one result of our rich and varied resources. We have the highest wages in the world. Our completeness of food, power, materials, factories, and machines enables us to produce so much of so many things that we can easily pay higher wages than any other country, and apparently we have the basis to maintain that differential for a long time to come. We have a national policy to see that these high wages do continue.

Holding wages high. When we get into international trade we find it necessary to use the power of government to protect this high wage standard. We see this with crystal clearness in an American ship, built at high wages, equipped with comfortable crew space, and



The finest and most beautiful building of its kind in the world—the U. S. Department of Agriculture, the temple of contradictions. There, three devils of the Age of Science congregate to torment the nation—Scarcity, Abundance, and Price. The Department tells the farmer a hundred ways to make abundance. He makes it, gluts the market, collapses price, feeds us well, and loses money. See Fig. 66. In the 1930's we feebly tried acreage reduction. In the 1950's we buy surplus and do not know what to do with it. Politically, it is *such* a hot potato—and very expensive. Is there any cure but real limitation of production? *U. S. Department of Agriculture*

operated by highly paid, well-fed crew. Result? It costs $1000 a day more to operate some American ships than it would cost to operate a similar ship built in Japan and registered in Panama or Liberia. Record-breaking big tankers were built in Japan in 1954 for American owners. Many American-owned ships sail under the flags of Panama, Honduras, and Liberia. They are free to use foreign, often Asiatic, crews and to pay low wages. They have low taxes in the registering country.

The United States tariff. The first law of the U. S. Congress was a tariff for revenue *and* protection. There has of late been much talk about a tariff reform by permitting the President to negotiate reciprocal agreements capable of administrative readjustment up or down. By this law, now in operation, he can raise the tariff on any commodity, if an American industry is "likely to be injured" by the import of that commodity. Recent examples show how it works. Because of complaints by American citizens that American industry was "likely to be injured," our President in 1954 denied some requests for raises but he did raise the tariff on Swiss watches, Swedish hardboard, and Italian almonds. These raises were made despite bitter complaints from Europe and the oft-expressed request for "trade not aid."

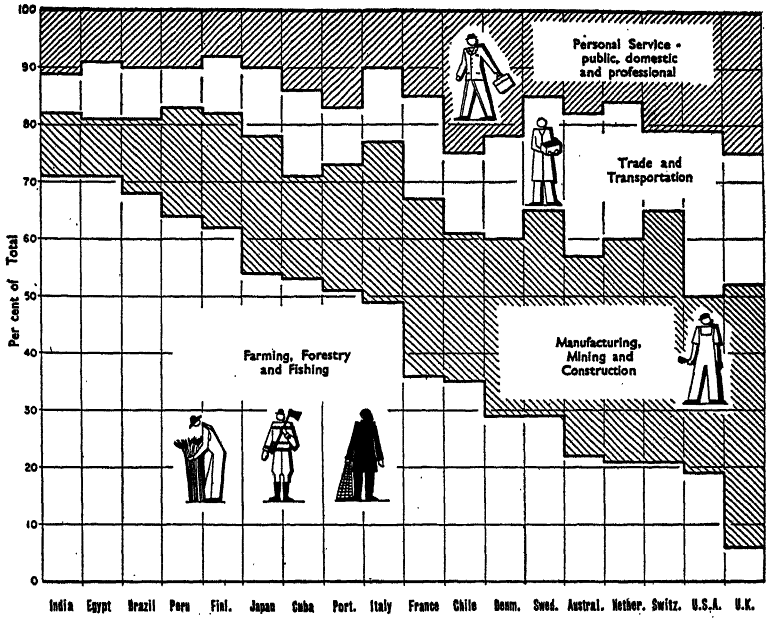
Also for some years Point Four staff had been showing Italian apple growers how to grow apples. American apple growers complained to Washington that this was building up competition. Orders from Washington stopped this bit of Point Four work.[2]

Andrew Carnegie is reported to have said that as soon as he learned that the tariff was a local matter, he got along all right.

Our 1954 tariff means this. Our watchmaker shall live in the United States, not in a foreign land.

The above-mentioned series of small episodes has a principle back of it, and the results for the present and for future decades seem to be this. We are going to support some watchmakers who make watches for us, some almond growers who grow almonds for us,

[2] Michael Hoffman, *The New York Times,* Oct. 3, 1954.



This chart might be called the wealth of nations. Compare the nations. Did you ever see a chart that told so much? Made before our last census, which reduced U. S. agriculture's share by about one third (see p. 68). *U. N., F.A.O. The Farm and City, Rome, 1953, p. 31*

and some hardboard makers who make hardboard for us. Shall they and many more like them live in a foreign land or in the United States? We seem to have decided for the present that we will as now pay them $6.00,[3] $10.00, $15.00, $20.00, or more a day and have them live in the United States rather than pay $2.00, $5.00, $8.00, or $10.00 per day and have them live in a foreign country.

We have no such option on commodities that nature prohibits us from producing, such as coffee, cocoa, bananas, and many minerals that nature did not give us. The trade in these is quite another matter.

Note the following to see how firmly set is this policy. If Japanese or Chinese operatives get $1 or $2 a day for operating good, modern automatic German or British textile machinery, free import of their product will close American textile mills in a few years *or* put American textile wage at a figure not greatly higher than that of the Oriental mills. Figure 537 shows clearly how wage differentials have moved industry from New England to our own southern states.

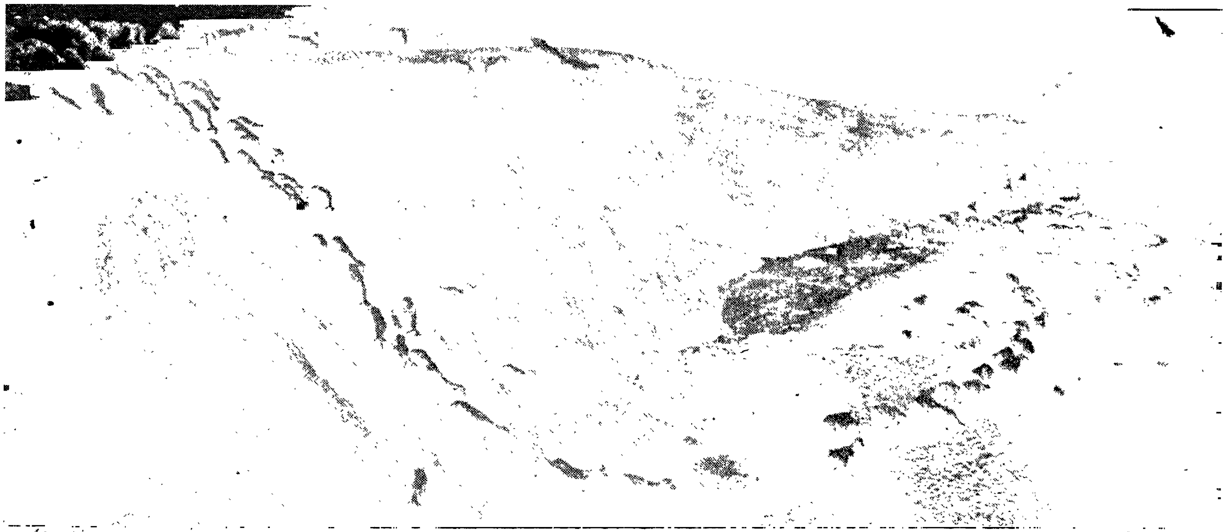
Policy real but not formally announced. We do not recall hearing this economic isolation announced as a permanent national policy by any important group. As we make the statement, we merely report something that already exists. We built up this isolation first by a series of general tariff acts. Recently Congress gave the President some discretionary power. Now he can change it bit by bit—watches, almonds, hardboards—on Mr. Carnegie's local-issue plan. Fig. 511 shows how this price-control method has already worked in the international field. In 21 years, 1931–52, U. S. cotton export, with price support, declined 60% or 5 million bales and foreign production increased 9 million or 75%.

There appears to be no other way to hold up the wages of cotton-growers' laborers. In 1955, with 600,000 steel workers getting $20 a day, you will have difficulty finding cotton-farm laborers able to get 290 days work in a year at $7.00 a day in the deep South and probably elsewhere.

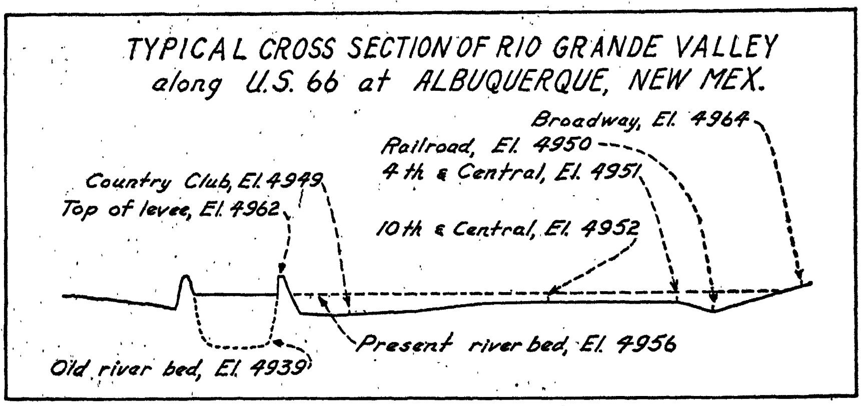
(g) Our Economic Isolation Is a Force Pushing Other Nations to Try Manufacturing

The people of the underdeveloped countries are up against a *situation* as well as an idea. Inability to buy our high-priced cotton, grain,

[3] *American high wages* is a loose term as shown by comparison of highly organized factory operatives and unorganized farm laborers, especially along our southern fringe—ratio often 1:3 or even 1:4.

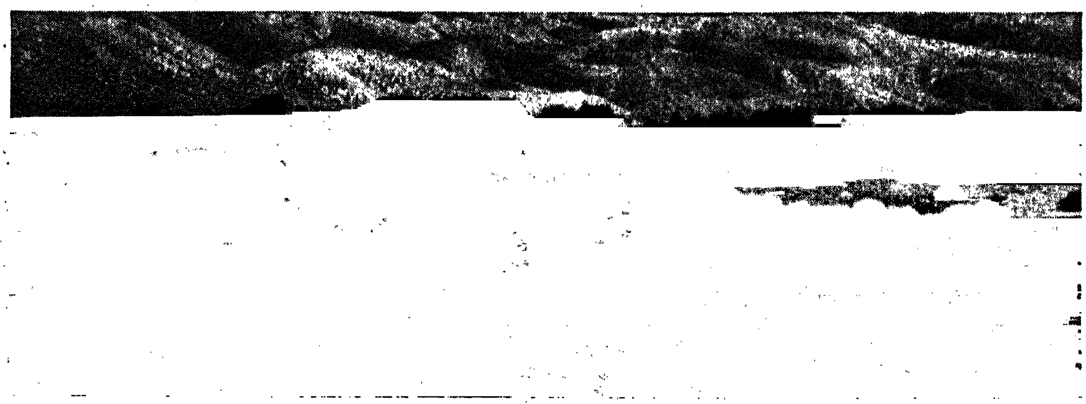


(Above) Regional Suicide, Part 1. Upland valley in New Mexico: filled 20 feet deep with silt, fin as meal, soft and rich. When Americans got there, grass was so high it hid explorers' horses. I flood, grass flattened out in front of the torrent, made a carpet. No erosion. Now overpastured b sheep. Shower water cuts the bare ground. Master canyon develops, eats up the valley with it ever-widening branches. *U. S. Department of Agriculture*



(Left) Regional Suicide, Part 2. Material washed from eroded upland filled the river. Dikes were built and still the river fills. Now see what a flood will do. The valley cannot drain into the river. Valley waterlogged, much of it ruined for crops. *Adapted from drawing by U. S. Bureau of Reclamation.*

(Below) Regional Suicide, Part 3. This stretch of sand, this larger stretch of Canada thistle was clear water a few years ago—the upper end of a reservoir for irrigation water. Every Rocky Mountain river carries silt from preventable erosion to fill reservoirs without which people must migrate. U. S. tax money built the reservoirs. Beavers do better. Fact, but not space to tell. Can a "free economy" be too free? *U. S. Bureau of Reclamation*



(Above) Regional Suicide, Cotton Belt variety. This much land in that climate would support a family indefinitely in China—does do it in China. Note last remnant of cultivation. *U. S. Soil Conservation Service. (Right)* Hillside ruin was checked by seeding to grass with enough fertilizer to make grass grow and hold the earth. *Tennessee Valley Authority*

(Below) Saving a South Carolina slope by strip cropping. All furrows at right angles to the slope: strips of bare ground are kept narrow so gullies cannot start. *U. S. Soil Conservation Service*

or simpler machines forces them to do without or to try to make for themselves on their lower wage level, if they can.

There is no reason to expect the United States to make any tariff retreat that permits a foreign supplier to knock out an established American industry of importance or to force a substantial cut in American wages. A few years ago the U. S. government advertised for bids for a big power plant at a Rocky Mountain dam. A British bid, tariff paid, was the lowest. We rejected it. Europe cried "trade not aid," but the rejection stood. By present law we will pay a U. S. bidder 9.95% more than a foreign bidder in above circumstances, tariff paid.

As time goes, our tariff will keep on starting and protecting still more infant industries in this country. Thus it appears that our tariff will stimulate production outside of the United States. Foreign capitalists now build branch factories here and Americans build branch factories in Canada and Europe to get behind tariffs. These plants are usually operated by 98–99% local labor. American and British and, to some extent, Dutch and French, are ready to build branch factories in many countries if they could be sure that the capital investment would be safe.[4]

How get your money home? Foreign investments promise another embarrassment to the Americans. We of the United States have abundant capital. If we should invest abroad on any large scale a new question will arise. How can the owners of the branch in Turkey or Chile get the dividends home? Profits must come as goods. American companies by the score are growling now about the hardship of having to pay tariff at New York on produce from their own mines and factories in foreign lands. This question promises to become more acute.

We have touched on these matters of tariff, surplus, price supports, and foreign investment because they are potent factors in the location and development of industry. Also they promise to be the basis of much discussion and legislation during the life of this book.

(h) Our Future Food Supply Demands Conservation of Natural Resources

Agricultural surpluses and policy are immediate, a short-time policy of the developed world. There is also a long-time policy that points toward scarcity such as now produces the misery of hunger to hundreds of millions of mankind. See Egypt, p. 70.

The American people are rich in large part because of our amazing and unrivaled material and climatic resources, especially food resources. Nature placed these resources in the land we have the luck to hold. Natural resources make raw materials for factory, farms, and home. The industries we have described in this book need material, and the large quantity and the rapid increase in rate of consumption are shown by many graphs. The minerals must go; perhaps we can substitute for them but food is different.

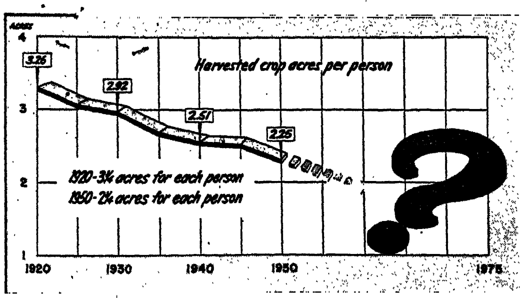
The first need of all people is food. Our base resource is land. If our people are to survive in strength and numbers their future depends upon the land now within our boundaries, and each year we have less crop land. We destroy some and make none.

Soil conservation is a tough problem, but real. The majority of our people now live in cities and need food from distant farms. The farmer in Georgia, Tennessee, Oklahoma, every state, is wasting the land to some extent, often needlessly wasting the land that is needed to feed you, and more especially your children and your children's children.[5] How

[4] This point was mentioned on page 8, but here are further references. "The United States investor often lacks confidence in the government of the resource country. If this obstacle could be overcome, most of the specific deterrents to investment would vanish."—An American Businessman quoted, President's Material Policy Commission, *Resources for Freedom,* Vol. I, 1952, p. 66.

More of the same can be had in a report "Factors Limiting U. S. Investment Abroad," U. S. Dept. of Commerce, 1954.

[5] See the work of the U. S. Soil Conservation Service. Also *Tree Crops, a Permanent Agriculture* by J. Russell Smith, New York, Devin Adair, 1953.



U. S. harvested acres. What is your share? What was your father's share when he was born? Signboard on the road to lacto-vegetarianism plus cow-meat sausage and a bit of pork and mutton now and then. Chinese diet plus milk. Next milk goes, as in China now. *U. S. Department of Agriculture*

can our city people, now a majority of U. S. population, persuade those distant farmers to save the land that will feed the future if it is to be fed? Here is a problem for all states and nations. Who solves it best lasts the longest.

(i) Capital Is Needed by the Underdeveloped Peoples so That They May Join the Industrial Revolution. Can the Developed Countries or the U. N. Aid Them to Get It?

On pages 9–14 we described the present capital shortage as it exists in most of the underdeveloped countries. We may say this shortage causes them to be underdeveloped. Must this situation continue?

Must the people of half a hundred little nations be half unemployed, or working hard but inefficiently at very low wages, and be hungry in the midst of unused resources, because the entire world of investors is afraid to put money within reach of their irresponsible governments?

At present an irresponsible government can say to the foreigners: Our acts are within our own borders. They are a local matter. We are a sovereign state. It is our business; it is not your business. For three years in Iran that philosophy kept $1500 million worth of oil equipment idle, in violation of a contract, while many Iranians were hungry, and their government near bankruptcy, through loss of oil income. National pride is a business factor. After years of waiting and months of negotiation, a patient and ingenious negotiator got the parties to sign and the oil refinery going again, making revenue for Iran, dividends for investors, also heat and power for many lands.

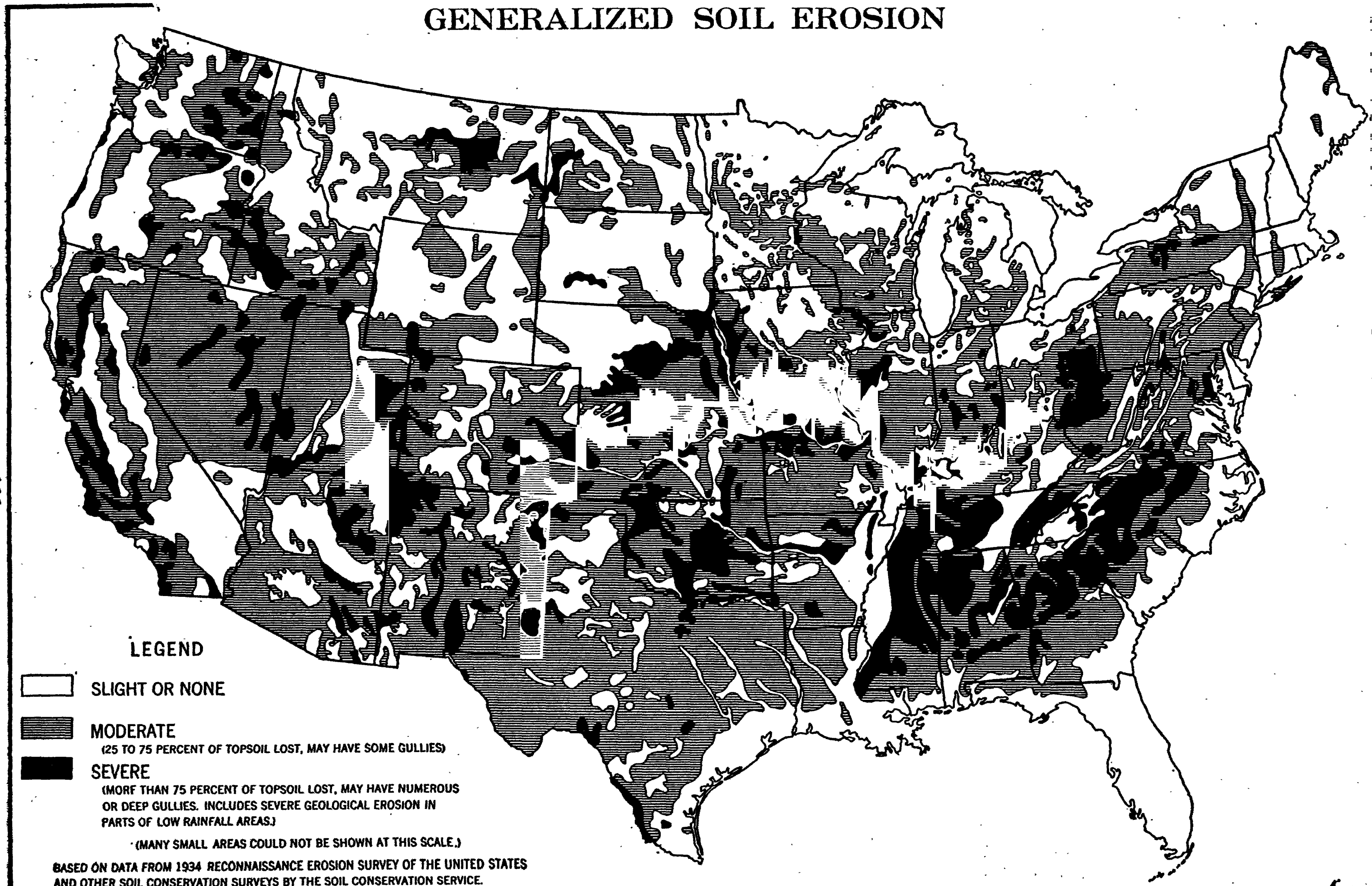
The need of something big. In the midst of war we envisaged the atom bomb. We really rose up. Platoons of scientists, thousands of artisans, billions of money were thrown into the enterprise. It succeeded, if we can call that bomb a success.

The investment problem is as big as war, not so immediate, but big. Can the West really rise up and tackle it? Here's a suggestion that may be worth thinking about. Suppose a group of persons experienced in international trade and finance spent the weeks or months necessary to make an international investment code that would be as fair as possible to the investor in the developed nation with capital to lend and to the people of the underdeveloped nation who might be seeking capital. When they try to bargain now both usually want the lion's share.

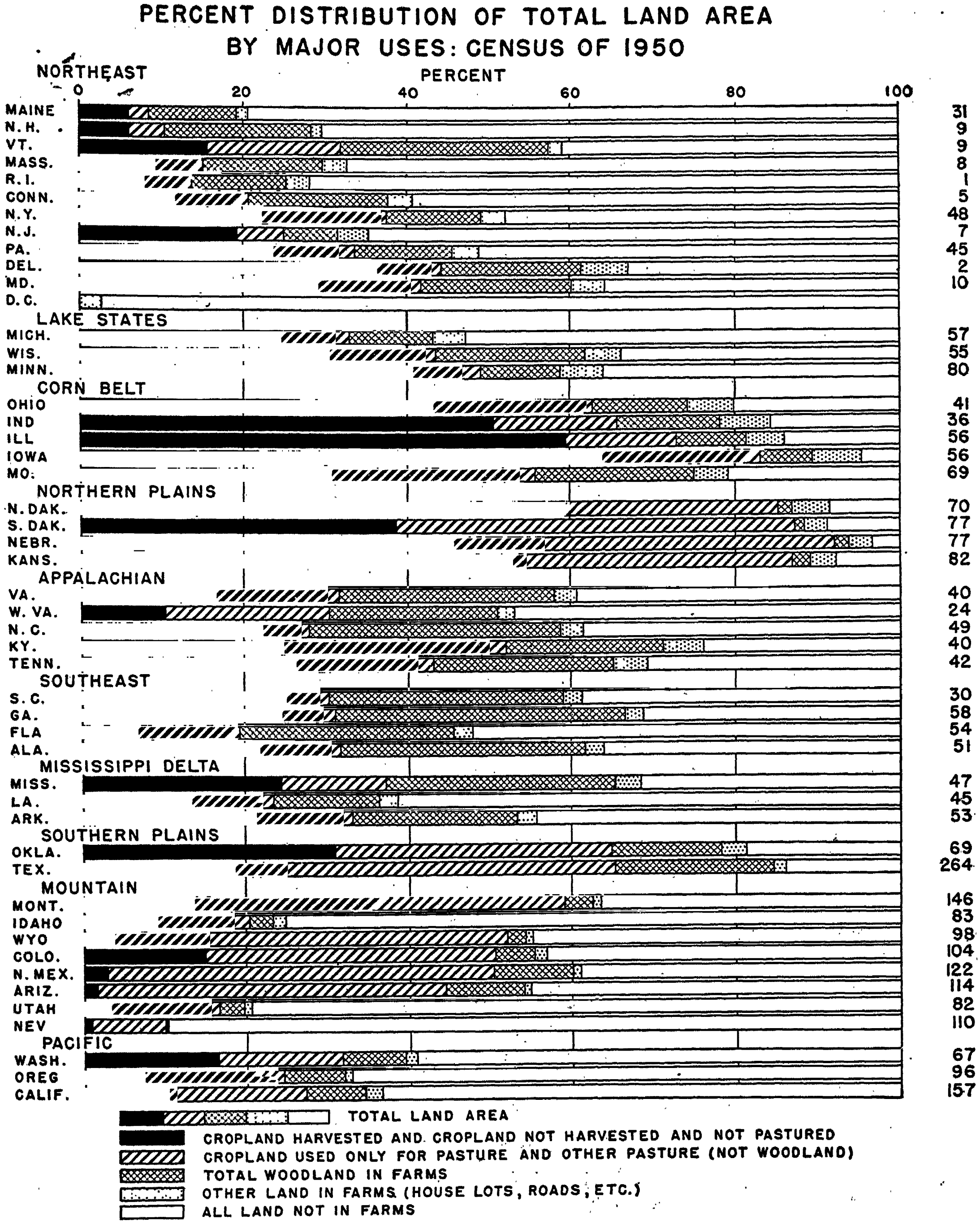
U. N. as referee? Suppose Sweden makes a treaty with the new and weak little dictator nation of Erehwon. This treaty provides that contracts between citizens of Sweden and citizens of Erehwon should be in accord with the U. N. foreign investment code. Copies of the treaty must be filed with U. N. Industrial Promotion Section. This treaty should provide that difficulties arising in its operation should be settled in the courts of the U. N. (World Court).

Violation by the Erehwonese of a world-court decision under such a contract might put them so completely in the yellow-dog class that U. N. might need no arm of power whatever to keep the Erehwonese as honorable as the Japanese were before World War I.

True, this contract is a big concession for a dictator to make, but it only needs one to start it. (Remember Turkey, pages 9–10.) Then too, dictators need money, cash in hand, and taxes that rise from business. Many of them have little but customs duty income and con-



A map of disaster. Here you see the location and extent of one of the gravest menaces to the long-distance future welfare of the American people. Our climate has the deluging thunderstorm, almost unknown in Europe. *U. S. Soil Conservation Service*



This page is really a small book about the United States. Each state is shown as 100%. Percent of what? Of the land area of the state. See column at right. Of Maine it is 31, of Texas 264 thousands of square miles. How many square miles of your state are black? *U. S. Department of Agriculture*

As one gets acquainted with the world, he is continually surprised at the small fraction of its surface that is good for crops and will stay good. Look at and explain Nevada, California, Utah, Maine, West Virginia, Louisiana. Where is the potential forest land; food reserve? When we are 400 million people, what states promise the greatest percentage increases in black; the most productive use of land not now in farms; the least growth?

fiscation. There is so little business to tax!

If this plan succeeded, business between the Erehwonese and the Swedes could prosper. Other countries, seeing this prosperity, might turn to U. N. for similar help. In time the U. N. might have district courts in various parts of the world as the U. S. has in different parts of the U. S.

Capital is not enough. When a government becomes such that an investor of capital is willing to invest under it, that will be a great step forward, but it is not enough.

Suppose a contract is agreed upon. Plans for the factory are drawn up. Think about the young people of some point in Asia, Africa, or Latin America who will have to move from village life they know so well to town or even a city or suburban fringe to jobs in a factory. The young man leaves the work he knows; he leaves family, friends, land, priest, and all that matrix of proprieties, of rules, customs, traditions, and local ceremonies that made an economic and social way of life for him. Perhaps he goes to work in a city factory, is herded into a shanty-town, landless slum. He has lost the world he knew and has not found another one. It is not there to find. He is homesick and lonely in a crowd of rootless people. Such a situation is the setting for frustration and discontent—a soil especially prepared for agitators and demagogues.

A factory is not enough. The investors arrive with building plans, machinery, and managers to lead production, but they also need an outside staff to plan, organize and help operate a *community*.

We are convinced that this transfer from rural village to urban industrial environment is of grave importance in modern civilization.

Does not enlightened self-interest require that the international investor sees to it that the worker has a chance to be healthy, happy, and educated to some useful extent?

From now on it promises to be dangerous, increasingly dangerous, to plunk down a factory in a wilderness or in a small town and let a festering unorganized, unserviced slum grow up beside it.

Town planning is now an advanced art. Why not apply the garden city idea, which provides room to play, to dig, and grow things, space for sports for the young and recreation for others. All these give relief from factory discipline and make normal outlet for healthy activities. Incidentally, it will make jobs for a number of experts who are not directly engaged in production. There is nothing revolutionary or even new about this. Dozens of companies in both Europe and America have done something like this.

We of the West will have betrayed our own civilization if we get the chance to invest in the underdeveloped countries and do not make our factory towns centers of civilization. That does not mean make Yankees of the people. The investor should help them to jobs, and help them to establish house, health, recreation, and education for themselves. Then when the agitator comes along telling pretty tales about some distant land, he will be told to "Go to! We have it here."

A recent Twentieth Century Fund (New York) study on "Approaches to Economic Development" has some such idea as this when it says that economic development "tends to be an external expression of the fundamental religious, moral and cultural beliefs and aspirations of the people" and "There must be a desire for economic progress coupled with determination to achieve it."

Can private enterprise do something here? The red tape of government is a very tough and entangling fabric, and the purple tape of U. N. will have difficulty being less so. Why isn't this a field of experimentation for foundations or for a multimillionaire or a group of them with imagination? Could a million be invested better for humanity than by financing the making of the above-mentioned code? Millions are set aside for use in less promising aims.

Benjamin Franklin, printer, made a little money early in life—enough to live on, very simply. He seems to have been no social swell, but he devoted his talents and time to civilizing the American colonies and later to helping make them into a nation. We have in the United States 1000 men who could retire at 45

Denmark, Norway, Netherlands, Belgium, and the heart of France, they paused at the shore and stood looking across the English Channel. For months they tarried in Belgium chanting in the streets, "Today we conquer England, tomorrow the world."

In presenting this bit of historical analysis Bertrand Russell makes the point that any nation may be captured from within by its own demagogue—dictator. Were not Hitler's captive Germans the most highly educated nation in the world? Certainly no one questions their personal capacity.

(b) The New Techniques for Tyranny Aid the Demagogue to Enslave Peoples

Perhaps the most awesome aspect of the age of science in the field of government is the new techniques for tyranny. There are so many new tools that the dictator (or any other government) may use to hold peoples down.

In the first quarter of this century the British discovered that one airplane, a small one, could quiet the troublesome tribesmen of the Northwest frontier of India as much as 35,000 soldiers. Just fly over the riflemen's country and drop bombs on herds and village. The riflemen subsided.

Consider the concentration camp with its barbed wire enclosure—that great tool of modern suppression.

What do dictators want to do? Dictatorship is the power lust in triumph. The lust for power is unique among man's desires. The exercise of all other passions leads to satiety and sleep. But in terrible contrast, the desire for power grows by gratification. It runs away with the human spirit, sometimes unbalances the mind. The Romans with the pitiful record of Emperors before them had a word for it, "Imperial Madness." The modern version is a saying attributed in part to Lord Acton and in part to Elmer Davis—"Power corrupts, absolute power tends to corrupt absolutely."

If you will study the work and motives of the founders of the U. S. Government, you will realize how diligently the founders strove to keep excess power away from any man or group. And they started a government by and with the consent of the governed. . . . Dictators do it differently.[8]

Hitler, crazed by power said, "Not by the cackling of Parliaments but by the regiments at the front."—gratification of the power lust —power for its own sake—to make the nation powerful—"Tomorrow we conquer the world."[9] What for? Search history and see for yourself what it is that dictators have done when they had absolute power.

(c) The World Struggle for the Minds of Men—Struggle without Precedent, without Parallel

The struggle will be long. It is a part of the continuing revolution.

The new powers of communication, especially the communication of ideas, like the other parts of the Scientific Revolution, are here to stay. They will be used by those whose desires are evil and by those whose desires are good. They are being used every day by the forces of dictatorship to promote and spread dictatorship. They are also being used by the forces of freedom. Are the forces of freedom doing as much as they should?

This book presents industries and commerce. Industries are operated by people. People are gathered together in nations. The nations have governments. In their desired types of government, the dictators and the free peoples struggle for the dominance of the minds of men, and thereby control nations resources, industries and the future.

The question is: Shall the world be a collection of dictator states in which thinking is

---

[8] In the process of building the monolithic state Adolf Hitler, disposing of a minority vote, massacred several million in his poison chambers, did it very scientifically. He did not get the chance to finish his plan of "Poland will be depopulated."

Examination of the careers of Joseph Stalin of the Soviet Union and his colleague Mao Tse Tung of China, 1949–55, will show more of the attitudes and acts of the real dictator toward his fellow men.

[9] If you happen to be interested in the dictator's view and a quarter-century of German history, you will derive profit from reading about half of Hitler's book, *Mein Kampf*.

The village is a thousand years old, but this is the first schoolhouse. The villagers built it themselves. The Indian government furnishes teacher, books, and slates.

The U. S. Foreign Operations Administration (FOA) (Point Four), the Ford Foundation, and other organizations are helping the Indian government with its community development project (health, crops, sports). Note the word *community*. It is not a financial investment. It is a feeling among people. *FOA photo*

dangerous and supreme courts are dismissed like a class of schoolboys,[10] *or* shall there be more and more states in which people have free speech, free press, free assembly, trial by due process of law, and opportunity for as much education as they can take. Our success in this struggle depends largely upon what we in the United States do with our minds when not working at our business jobs.

What can one person do in this struggle? We all live under a deluge of words—truth, trivia, trash and lies, newspaper, magazine, book, radio and TV. Also we live and will continue to live under a shower of reasonably correct fact and matured opinion. Which do you believe? The individual with a measure of horse sense has a lie detector, is not easily gullible, and is less likely to be meat for the ever-present demagogue.

Eternal vigilance is the price of liberty and the time is now. Governments don't stay good. They are kept good by good citizens who work. Individuals become effective through organizations. There are hundreds of organizations working for human betterment. You will hear of them continually. Perhaps you are a member.

We must keep our country on the even keel of freedom under which it started, but keyed now to the new facts of today. Communication must be used to spread truth and information around the world more diligently than the dictators are spreading lies. The people in Pike Town, Possum Hollow Road, and Broadway can now lift their sights to include the people of the developed and the underdeveloped countries of the world.

[10] It was reported, Feb. 10, 1955, that six members of the Russian Supreme Court had been dismissed and seven more appointed. How completely shattering to a government as the West know government.

Index

Footnotes and illustrations have not been indexed, and only the most important place names have been included.

abacá (Manila hemp), 526-27
aeronautical science, developments, 646-47
aeropolitics, 647-48
Africa, camels in, 26; caravans, 610; grassland civilization, 49-51; inland waters, 611-12; millet and sorghum, 122; primitive agriculture, 58-59; railroads, 610-11; sorghum, 183; trade of, 609-10; water power, 329, 335, 337. *See also* French North Africa; North Africa; West Africa; Union of South Africa
agricultural glut, problems of, in U. S., 63-68
agricultural machinery, 438-41
agriculture, with domestic animals, 59-60; extensive, and poultry keeping, 239; export problems of nonmanufacturing countries, 69; intensive, and citrus fruits, 147, dairying as, 230, 232, and potatoes, 131, and poultry keeping, 239, and sugar-beet production, 164, 166-67, and tobacco production, 203; and the Machine Age, 68; mechanization of, 62-63; plantation, 49; primitive, in Africa, 58-59, in Asia, 32-33; problem of surpluses, 63-69
Air Age, 643-46
aircraft industry, 450-54; development of, 646-47; statistics on, 646, 647
airlines, growth of, 644, 646; statistics on, 644, 646
airplanes, 453-54; travel by, 628
airways of the world, 643-52
Akron, Ohio, rubber manufacturing center, 265, 266, 267
Alabama, peanut production, 238
Alaska, coal industry, 295; dogs in, 24; fishing, 250; forests, 489-90; fur seals, 251; Indians of, 21; railroads, 582-83; trade of, 639-40; U. S. troops in, 4
Alaska Railroad, The, 582-83
Albania, railroads, 602; sheep production, 217
Alberta, Canada, petroleum, 315-16
alcohol, 309, 326
Alexandria, Va., as port, 563
alfalfa, Argentina, 214, 223; U. S., 220, 242
Algeria, tobacco growing, 205
Allied Chemical Corp., 464
Allis-Chalmers Manufacturing Co., 441
alloys, 351, 408-09
allspice, 200
alpaca, 217, 517
aluminum, 395-402
Aluminum Company of America (Alcoa), 395
Aluminum Company of Canada, 401
Amazon Basin, railroads of, 593
Amazon River, 330, 332, 596
America. *See* Caribbean America; Central America; North America; South America; names of specific countries
American Cyanamid Co., 474
American Indians, civilization of, 57, 58; and corn growing, 105-06
American Locomotive Co., 442
American people, amounts of foods consumed, 245; meat consumption of, 207, 209, 216; types of foods consumed, 241
American Smelting and Refining Co., 388
American Tobacco Co., 206
American Viscose Corp., 490
American Window Glass Co., 431
Amsterdam, as entrepôt center, 570, 572; as finance center, 276
Anaconda Copper Co., 388, 417
Anglo-Iranian Oil Co., 8
Angola, coffee production, 190, 191
Angora goat, 218, 518
animal energy, 22-26; comparative costs of, 42-43
animals. *See* draft animals; domestic animals; names of specific animals, *e.g.*, beef cattle, sheep
animate and inanimate energy, 18-44
Antarctica, 56
Appalachian Valley, apples, 141-42
Apperson brothers, 444
Appleby, John, 81
apples, 139-44
Arabia, U. S. interest in oilfields, 2
Araucanian Indians, 21
Arctic regions, animals of, 24; climate of, 56
Argentina, alfalfa, 214; beef cattle, 218; beef and veal exports, 222, 223; climate of, 21; corn belt, 111-12, 115; corn exports, 114; flax, 118, 119; goats, 217; grazing, 112; hides, 254; hog raising, 112; inbound and outbound shipping, 618; meat consumption, 207; meat-packing industry, 228; ocean trade of, 631, 632; paper industry, 504; petroleum, 317; ports, 565, 567; quebracho extract, 255; railroads, 592; rainfall, 214; rye, 118; sheep production, 214-15, 216; shoe industry, 259; sugar cane, 173; tallow, 475; tanning industry, 255; tobacco import duties, 206; waterways, 597; wheat, 84, 91; wine, 156; wool, 516
Arizona, copper, 387-88; cotton, 511
Arkansas, rice growing, 102
Arkwright's water frame, 531, 536
Asia, ancient civilizations, 47; barley growing, 122; cacao exports, 196; caravan routes, 607; cattle in, 219; climates of, 51; coffee, 185, 187; corn growing, 115, 116-17; energy in, 32, 33; European trade of, 635; fishing, 252-53; ginger, 199; handicraft industry, 269; importance of camel to, 26, of elephant to, 26, of oxen to, 24, of rice to, 94, 95, of Suez Canal to, 640; inland waterways, 608-09; and Medi-

terranean trade route, 632-36; millet and sorghum production, 122; Pacific trade routes, 637-39; petroleum, 321; railroads, 606-09; rice growing, 96, 97-100; rice trade, 103-04; rubber, 262-63; sheep production, 216-17; sorghum, 183; statistics on, 652; tea growing, 192-93; tobacco production, 204-05; trade centers, temporary, 561; trade obstacles, 606-07; trade within, 634; wheat growing, 88-89; wheat imports, 93. *See also* Oceania; Southeast Asia; names of specific countries
asphalt, 308, 309
Assam, rubber, 263
Atlantic Ocean, fisheries, 247-49; trade routes, 626-30
Atlantic Plain, canning industry, 161-62; truck farming, 125-26, 132, 133
Atomic Age, 339
atomic energy, 339
Atomic Energy Commission, 339
Australia, beef cattle, 218, 219; beef and veal exports, 222, 223; climate of, 21; coal industry, 300-01; copper, 393; dairy industry, 235; dried fruits, 160; eucalyptus tea, 195; export problems of, 71; forests, 495; gold, 416; grape and wine industry, 155; meat consumption, 207; meat-packing industry, 228; mutton and lamb, 213, 214; oranges, 147-48; railroads, 612-13; rainfall, 213-14; sheep production, 213-14, 216; shoe industry, 259; silver, 417; skins, 254; South African shipping routes to, 636-37; steel industry, 377; sugar, 180; tallow, 475; tanning industry, 255; trade routes to North America, 638; uranium, 339; wheat, 80, 90, 91; wool, 213, 214, 516
Austria, porcelain, 429; wool manufacturing, 542
automation, 655, 656, 658
automobile industry, 444-50
automobiles, and rubber industry, 261

bagasse, 176, 500, 504
Bahia, cacao production, 197; tobacco shipping, 205
Baker, O. E., 74
Baldwin Locomotive Co., 442
Baltic Exchange, London, 575, 617
Baltimore, Md., as seaport, 565, 568; tidal range, 566
bamboo, 493
bananas, 137-39
bargain center, the 573-78
barley, 120-22
barter, 561
basic slag, 470
bauxite, 397-98, 401, 402
beasts of burden. *See* draft animals
beef, jerked, 223
beef cattle, 218-25
beef extract, 223
bees, 242; and buckwheat, 123
beeswax, 242
beet-sugar industry, 164-72, 180-83
Belém, as rubber port, 261
Belgian Congo, coffee production, 190; diamonds, 420; palm oil, 238; peanuts, 238; tin, 407; uranium, 339
Belgium, anthracite production, 285; cement, 427; coal, 291, 296, 301; coal consumption, 286; cotton-textile industry, 535; flax, 524; glass industry, 432; iron and steel, 343, 370; locomotive manufacture, 443; mineral consumption, 282; rabbits, 242; sheep production, 216; textile machinery, 438; wheat yield, 86; wool manufacturing, 542
Bengal, jute, 525-26
Benz, Carl, 444
benzol, 326
Bergen, Norway, 565, 566
beryllium, 339
Bessemer process, 346
Bethlehem Steel Corp., 361; South American mines, 596, 632
Birmingham, Ala., steel industry, 362
Birmingham, England, 366
Black Sea-Mediterranean trade, 634
blast furnace, 345
Boeing Airplane Co., 453
Bogotá, Colombia, 595-96
Bolivia, corn growing, 115-16; petroleum, 317; railroads, 594; rubber production, 261; tin, 406-07
Bolivia & Antofagasta Railroad, 594
Bombay, cotton mills, 538
Bonneville Dam, 335, 336
Bonneville Power Administration, 334
Boston, Mass., as port, 568; as shoe center, 575; wool market, 517
Boulder Dam. *See* Hoover Dam
Brazil, Amazon River, 596; beef, 218, 222, 224; cacao, 196, 197; cane-sugar industry, 183, 189; coal production, 295; coffee, 184-85, 189-90; coffee exports, 631; corn growing, 113; cottonseed oil exports, 238; forests, 495; goats, 217; hides, 254; hogs, 225, 226; hydroelectric power, 331; iron and steel industry, 344, 362, 377-78; meat-packing industry, 228; ocean trade of, 631-32; oranges, 148; paper industry, 504; petroleum, 317; Plata-Paraná-Paraguay waterway, 597; railroads, 593; rubber production, 261; shoe industry, 259; sugar-cane production, 173; tanning industry, 255; tea exports, 194; textile manufacturing, 553; tobacco, 201, 205, 206; U. S. money invested in, 13; water power, 337
breeds, beef cattle, 221; dairy cattle, 229; poultry, 239; sheep, 212
brick industry, 422-23
briquettes, 285, 303-04
British Columbia, Canada, salmon fishing, 250; water-power development, 12, 15, 16, 336
British East Africa, wattle bark and extract exports, 255
British Guiana, rice growing, 100; sugar industry, 180
British West Africa, ginger, 199
British West Indies, sugar industry, 180
Bronze Age, 380
Brooks, R. C., 21
Brussels Sugar Convention, 1902, 171, 172
Bryce, James, 12
Buck, Pearl, 33
buckwheat, 123
Buenos Aires, Argentina, meat-packing plants, 228; as port, 565, 567, 592, 597
buffalo, 219
Buffalo, N. Y., flour milling, 89, 90

Bulgaria, corn crop, 113; sheep production, 217; tobacco production, 205
buna-N rubber, 264, 308
buna-S rubber, 308
bunker coal, 289, 290; for ocean shipping, 632, 633-34, 637, 638, 639
Bunsen, Robert, 402
Burma, rice trading in London, 576; waterways, 609
Butte, Mont., copper mining, 386-87; silver mining, 417; zinc mining, 412
butter, 231, 232, 233; stored by U. S., 64
butyl rubber, 264, 265
by-products, coal industry, 304, 472; of coke ovens, 472; of copper smelting, 381, 416; from cotton, 509; of iron and steel industry, 469-70; of meat-packing, 228; naval stores as, 498; of petroleum, 308-09; of poultry industry, 239-40; silver as, 416; of sugar industry, 132, 166-67, 176

cacao, 195-98
Cairo, Egypt, cigarette manufacture, 205
Calcutta, India, as port, 565
California, airplane manufacture, 453; apple growing, 556; barley growing, 121; canning industry, 162; cement industry, 427; chicken production, 240; citrus fruits, 150-51; cotton, 511; fishing, 251; grape and wine industry, 157; hydroelectric power, 331, 336; lumbering, 487; mustard production, 200; natural gas, 326; peaches, 145; petroleum, 315, 323; rice growing, 102-03; rubber manufacturing, 266; steel industry, 363; synthetic rubber production, 265; turkey production, 240; vegetables, 125, 127, 133-34
camels as draft animals, 26
camphor, 193
Canada, aluminum, 395, 401; apples, 143; automobile industry, 450; coal industry, 294-95, 303; copper, 391-92; dairying, 232; fishing industry, 245; flax, 118; forests, 488; fur farms, 260; gold, 415-16; grain traffic, 588; high standard of consumption, 5, 6; iron and steel, 363-64; lumbering, 488; natural gas, 327; nickel, 408, 409; oats, 119, 120; Pacific ocean shipping, 639; petroleum, 315-16, 323; pipe lines, 588; platinum, 418; railroads, 579, 583-84; rye production, 118; salmon canning, 250; shoe industry, 259; silver, 417; U. S. money invested in, 2, 13; uranium, 339; waterways, 591, *see also* Great Lakes; wheat, 84, 85, 90, 91
Canadian National Railroad, 583
Canadian Pacific Railroad, 583
Canal Zone, cows, 224
Canberra, Australia, location of, 563
cane-sugar industry, 172-83
canning, of fish, 251; of fruits and vegetables, 160-63; of milk, 232; of salmon, 250
Cape of Good Hope shipping routes, 636-37
Cape Horn-New Zealand trade route, 637
Capetown, and shipping routes, 636-37
capital, availability of, 13; and bargain-center trade, 576-77; for chemical research, 464; for Chilean copper, 389; difficulties for foreign, 8-9; importance of, to economic status, 6-8; for Iranian oil industry, 320; for manufacturing, 267, 268, 276; need for, by underdeveloped countries, 577, 665, 668-69; for Venezuelan oil industry, 316
caravans, of Africa, 610; Asian routes, 607
Cardiff, Wales, 289
Caribbean America, citrus fruits, 148; rice imports, 104; shipping routes of, 630; sugar, 180, 181. *See* names of specific countries
Carnegie, Andrew, 660, 661
carp, 245
Cashmere goat, 517
Caspian Sea, 586
cassava, 135-36
cassia, 199
Catalan forge, 345
cattle. *See* beef cattle; dairy cattle
cattle ranches in U. S. West and South, 220-21
cayenne pepper, 199
ceará rubber, 263
celluloid, 480
cellulose, 479, 481
cement, 270, 425-27
Cement Age, 426
Central America, bananas, 138-39; corn growing, 115-16; coffee production, 187, 188; primitive agriculture, 58-59; railroads, 584-85; rice growing, 100; sugar cane, 173. *See also* specific countries
centralized bargaining, advantages of, 574-75
Ceylon, cinnamon, 199; coconuts, 237, 475; rice growing, 98, 100; rubber production, 262; tea production, 194
Chapman, John, 140
charcoal, 345, 372
chartering of ships, 617-18
cheese, 231-35
chemical industry, 462-64; developments of, 657; raw materials, 464-67
Chemical Revolution, 461
chestnut wood, 206
Chicago, Ill., meat-packing industry, 227; oil refineries, 323; railway-car manufacture, 442
Chicago Drainage and Ship Canal, 590
Chicago-Gary steel district, 357, 363
chicken production, selected countries, 240-41
chicle, 497
Chile, climate, 21; coal production, 295; copper, 388-90; forests, 495; iron and steel industry, 362, 377-78; meat-packing industry, 228; nitrate shipments, 632; nitrates, 471-72, 473; paper industry, 504; petroleum, 317; railroads, 593-94; shoe industry, 259; sodium nitrate production, 281; wine, 155
China, caravan routes, 607; cattle raising, 224; climate and crops, 47; coal, 300; corn growing, 116-17; cotton-textile industry, 539; fertilizers, 470; foreign trade of, 559; forests, 493; goats, 217; hog production, 225, 227; living problems in, 62; millet and sorghum production, 122-23; native culture, 550; paper industry, 504; peanuts, 238; poultry industry, 241; railroads, 608; ramie, 524-25; rice growing, 94-100 *passim*; rice trade, 103; seaports, 573; sheep production, 217; silk production, 520; standard of consumption, 33; soybeans, 130; spices, 199; sugar production, 183; sunflower seed oil, 238; sweet potatoes, 135; tea industry, 192-93; tin, 406;

tobacco production, 201, 204; waterways, 608-09; wheat growing, 88-89
chocolate. *See* cacao
chromite, 256-57, 279
chromium, 351
Chrysler Corp., 448
Chuquicamata, 388-89
cigarettes, 201, 204, 205, 206
cigars, 204, 206
Cincinnati, Ohio, machine-tool manufacture, 435
cinnamon, 199
cities, classification of, 562; locating of, 563; origins of, 561-62
Ciudad Bolivar, Colombia, 596
civilization, and climate regions, 18-22, 50; prehistoric, 18, 22, 105, 243, 267, 345, 380, 421, 530; of river-bank regions, 60, 62
clams, 249
clay, 422-23
Cleveland, Ohio, oil refineries, 323
climate conditions, for abacá production, 526-27; for bee keeping, 242; for beef cattle, 218-19, 223-24; for buckwheat, 123; for cacao production, 196-97; for coconuts, 237; for corn, 106; for coffee, 186-87; for dairying, 231, 232, 235; and manufacturing, 277; for maple sugar, 183; for millet and sorghum, 122; for mustard, 200; for oats, 119; for peaches, 145; for poultry, 242; for ramie, 525; for rye, 117, 120, 121; for sheep raising, 211, 212, 214, 217; for sugar beets, 166, 168; for sugar cane, 173; for tea culture, 192; and trade, 556-57; for vegetables, 127, 128, 130, 134
climate regions of the world, 45-56; effects of, on man, 18-22
clothing industry, 546-49
cloves, 200
coal, 270, 271, 272, 283-305, 325-26, 333, 355, 366-70; Great Lakes traffic in, 587. *See also* bunker coal; coking coal
coal oil. *See* kerosene
coal tar dyes, 476-78
cobalt, 351
cocoa. *See* cacao
coconut oil, 475
coconuts, 237
coffee industry, 184-91; valorization in, 189-90
coke, 304, 308, 345
coking coal, 288, 289, 293, 295, 298, 299, 304, 372
"cold rubber," 264
Colgate-Palmolive-Peet Co., 476
Colombia, Amazon River in, 596; beef cattle, 224; coffee, 185, 188-89; coal production, 295; coffee traffic, 595; corn growing, 115-16; importance of Magdalene River to, 594-95; mangrove bark exports, 256; Orinoco River, 596; petroleum production, 316-17; railroads, 594, 596; rubber production, 261; tobacco, 205
Colorado, abandoned mines, 555; lettuce growing, 556; marble, 425; steel industry, 362
Colorado River, 330
Columbia River, 336, 401
commerce. *See* international trade; trade
commodities, bargain-center trade in, 473-78; grading of, 573
communications, modern powers of, 669-71
concrete, 426
condiments, 184-201
Congo River, 330, 332, 611
Connecticut, machine tools, 435; rubber manufacturing, 266
Connecticut River Valley, tobacco production, 204
conservation, of natural gas, 327; of water, 328
Consolidated Edison System of New York, 42
Consolidated Vultee Aircraft Corp., 453
Constantinople as entrepôt center, 570
consumption, of aluminum, 396-97; of apples, 140, 142; of cacao, 196; of coal, 287; of coffee, 184, 191; of dairy products, 229; of fertilizer, 474; of fiber raw material, 505; of foods in America, 245; of lumber, 490; of meat in U. S., 207, 221; of minerals, 282; of natural gas, 327; of paper and paper products, 503, 504; of peat, 284; of rubber, 265, 266; of sugar, 164; of sulfuric acid, 465; of tea, 184, 191, 192; of tobacco, 200-01
continental interior climate, 53; and wheat growing, 75-78
conuco, 58
cooperatives for eggs, 241-42
copper, 380-94; blister, 384, 394; concentrates, 383-84, 394; matte, 384, 394; secondary, 385; uses, 381-82
copra, 237, 475
cordovan leather, 218
cork, 492-93
corn, 105-16
Corn Belt, U. S., 106, 107, 108-11; barley in, 121; cattle ranches of, 221, 227; climate of, 54, 74, 75; fertilizers used in, 474; hog production in, 225-26, 227; oats in, 119-20; poultry industry in, 239; windmills in, 337
corn belts, 54
corn oil, 109, 238
Corning, N. Y., glass making, 431
Corriedale sheep, 213
Cort, Henry, 346
cotton, 505-15; British control of U. S., 577; importance of, to Egypt, 70-71; long-staple, 511; and tea culture, 192; U. S. exports, 661; U. S. price support, 559
Cotton Belt, U. S., 509-11; climate of, 47, 74; corn growing in, 111
cotton gin, 531
cotton-textile industry, 532-40; history and characteristics of, 530-33; migration of mills, 553
cottonseed oil, 238, 475, 509
Crompton's spinning mule, 531
Crown-Zellenbach Lumber Co., 487
Cuba, cane sugar, 173, 174, 176, 178-79, 180; copper, 392; henequen, 528; rice imports, 104; tobacco production, 204; tobacco trade, 556
culture pearls, 253
Czechoslovakia, coal, 286, 296-97; glass industry, 432; iron and steel, 372; lignite production, 285; porcelain, 429; shoe industry, 259; uranium, 339; wool manufacturing, 542

Daimler, Gottfried, 444
Dairy Belt, U. S., 231
dairy cattle, breeds, 229

dairy industry, 229-35
dairy substitutes, 235-38
Danube Basin, corn exports, 114; corn growing, 113; wheat growing, 87, 90, 91, 92
Danube River, 604
Darby, Abraham, 345
dates, 158-60
De Beers Consolidated Mines, Ltd., 420
Deere & Co., 441
Delaware, canning industry, 162
Delaware River, explosives manufacture, 467; shipbuilding, 457-58
Denmark, bacon and ham exports, 226; barley growing, 121; butter production, 232, 233-34; egg production and marketing, 241-42; meat consumption, 207; meat exports, 68, 207; shipbuilding, 456
Denver, Colo., sheep slaughter, 215
desert climate, 51
Detroit, Mich., automobile industry, 277, 445
developed countries, achievements of, 5; and capital, 7
Diamond Trading Co., 420
diamonds, 418-20
dictators, and power, 670
Diesel engines, 303, 438, 620, 622
diet, American, 124, 132, 245; ancient and medieval peoples, 198; Japanese, 252. *See also* standard of consumption
dirigibles, 452
distillation process, petroleum, 322
dogs as draft animals, 24
doldrums, and cacao production, 197
domestic animals in agriculture, 59-60
Dominican Republic, cacao production, 197; coffee, 185, 188; primitive agriculture, 58-59
Donets Basin, coal, 298-99, 373-74
donkeys, 23
Douglas Aircraft Co., 453
Dow Chemical Co., 402, 403, 404, 474, 523
draft animals, 22-26
Drake, Edwin L., 306, 315
ducks, 240
Dunlap Rubber Co., 266
Du Pont de Nemours & Co., E. I., 10, 11, 464, 523
Durham, N. C., cigarette manufacturing, 206; tobacco market, 203
Duryea, Charles E., 444
dyestuff industry, 476-78

East Asia, entrepôt ports, 573
East India Company, 184
East St. Louis, Ill., meat-packing industry, 227-28
Eastern North America, Asian trade of, 635; ocean shipping, 628, 629, 630; steel district, 360-62, 363
Eastern Shore, truck gardening, 126
Ecuador, cacao production, 196, 197-98; coffee, 185, 188, 189; corn growing, 115-16; petroleum, 317; railroads, 594; rubber production, 261
Eddystone, Pa., locomotive manufacture, 442
Edison, Thomas, 43; rubber experiments, 263; quoted, 655
Edwards Plateau, and animal-raising industries, 215, 218
eggs, 238-40
Egypt, corn growing, 116; cottonseed and oil exporter, 238; Nile River transport, 612; and Suez Canal, 8; trade problems of, 69-71
Elbe River as waterway, 603
electric furnace, 348-51
electricity, 272, 277, 328, 334; and copper, 381-82
elephants as draft animals, 25, 26
El Salvador, cacao-shipping port, 197; coffee exports, 185, 188
energy, relation of, to population, 7; role of animate and inanimate, 18-44
England, chinaware, 429; cutlery, 460; mustard, 200; steel industry, 366; sugar-beet production, 166, 168; wool-manufacturing industry, 542. *See also* United Kingdom
entrepôt center, the, 569-73
entrepôt trade, decline of, 572; definition and development of, 569-70
environment. *See* climate conditions
equatorial forests, 47-49
Erie Canal, 565, 581, 590
Eskimo, 56; agriculture of, 57; life of, 19-20
Ethiopia, coffee production, 190
Eurasia, population, 633
Europe, Asiatic trade of, 635; barley growing, 121-22; beef cattle, 221-22; calfskin exporter, 254; climate features of, 21, 52, 54, 55; coffee market, 185; copper, 392; dairying, 232; entrepôt centers, 570, 572; entrepôt ports, 572; and export of capital, 578; fisheries, 246-47; foreign trade of, 552-53; forests, 490-92; hog production, 225, 226; inland waterways of, 598-99, 602-04; lumbering, 491; meat consumption, 207; oats, 119; ocean shipping, 628-30; passenger ports, 567; peripheral, 34; ports, 117; potatoes, 131-32; railroads, 599-602; railroad mileage, 579; rice growing, 101; rice introduced, 95; rye production, 117-18; seaports, 565-66, 567; seaports and hinterlands, 564; sheep production, 216; statistics on, 652; tariff barriers, 599; tobacco production, 205; trade advantages, 598-99; trade with South America, 631; trading centers, 561; water power, 335; wheat production, 85-87; wheat trade, 90, 91, 92. *See also* Mediterranean Region; North Europe; U.S.S.R.; West Europe; names of specific countries
European Recovery and Defense spending, 2
exchange, the, described, 574, 575, 576
explosives, 467
exports. *See* international trade

Falconbridge Nickel Mines, Ltd., 410
Falkland Islands, per-capita trade, 560; sheep production, 211-12; statistics on, 560; tallow, 475
Farben, I. G., 464
Farm Bloc in U. S. Congress, 65
farm population, U. S., 63
farmers, problems of U. S., 63-67
farming. *See* agriculture; specific crops, *e.g.*, corn, wheat
Faroe Islands, sheep production, 212
fashion industry, 549
fertilizer industry, 467-74
fertilizers, and rainfall, 474; sources of, 468-73; and tobacco, 202
figs, 158

finance. *See* capital
Finland, lumbering, 491; paper industry, 504
Firestone Tire & Rubber Co., 265
fishery, defined, 243
fishing industry, 243-53
flax, 118-19, 523-24, 546
flaxseed, 118
Florentine leather, 258
Florida, citrus fruits, 149; fertilizer plants, 473; phosphate rock, 468; sponges, 249; tobacco production, 204; vegetables, 125
flour milling, 80-81, 89-90
food, basic need of people, 664-65; as export problem, 67-71; historical survey of, 57-63
food gatherer, 57
foods, composition of, 208; dairy products as, 229-30; new possibilities, 657-58
Ford, Henry, 444, 445
Ford Motor Co., 447, 448
foreign investment. *See* capital
forestry, scientific, 502-03
forests, 481-503; Great Northern, 54-55; national, 482-85; species, 486-87, 488, 492, 496-97; tropical, 47-49, 495-97
Formosa, tea, 193
fossil fuels, 43
Fourco Glass Co., 431
France, aircraft production, 454; aluminum, 401; automobile industry, 450; beef production, 222; butter and cheese production, 232, 233; cement, 427; coal, 296, 303, 336, 368-69; coal consumption, 287, 368; cotton-textile industry, 535; flax, 524; forestry, 492; glass industry, 432; hides and skins exporter, 255; inland waterways, 604; iron mining, 343; jute, 526; leather making, 257, 258; mineral consumption, 282; petroleum, 323; porcelain, 428-29; potatoes, 132; rabbits, 242; rayon industry, 522; rubber manufacturing, 266; sheep production, 216; shipbuilding, 456; silk manufacture, 544; sugar-beet production, 167, 171; sulfuric acid, 465; textile machinery, 438; tobacco, 205, 206; water power, 336; wheat, 86, 92; wine industry, 152-54; wool manufacturing, 542
Franklin, Benjamin, 668
French North Africa, coffee production, 190; goats, 217; peanut exporter, 238; phosphate rock, 468-69
fruits, 137-63; canned, 144, 149-50, 160-63; citrus, 145-51; dried, 157-60; frozen, 149-50, 163
Frye, William, quoted 14
fuel, coal as, 286, 303; electricity as, 303; natural gas as, 327; oil as, 287, 290; wood as, 481, 490
fur farms, 260
fur seals, 251
furniture, 498-99
furs, 259-60

gas, natural, 270, 304, 309, 312, 326-27, 430
gas coal, 288, 295
gasoline, 308, 311, 325-26
General Motors Corp., 447, 448
Georgia, fertilizer plants, 473; granite and marble, 424, 425; peanut production, 238; rice growing, 101
Germany, aluminum, 402; anthracite coal production, 285; automobile industry, 450; barley growing, 121, 122; beef production, 222; cement, 427; chemical industry, 462-63, 465, chemistry training in universities of, 551; clock making, 460; coal, 286, 295-96, 301, 303, 336, 367-68; cotton-textile industry, 535; cutlery, 460; dye industry, 478; forestry, 492; glass industry, 432; hides and skins, 255; Hitler's activities in, 669-70; inland waterways, 602-04; iron and steel, 343, 367-68; jute, 526; lignite, 285; locomotive manufacture, 443; magnesium, 402; minerals, 282; peat consumption, 284; porcelain, 428; potash, 470; potatoes, 132; rayon industry, 522; rubber manufacturing, 266; rye production, 117-18; silk manufacture, 544; synthetic rubber production, 264; sheep production, 216; shipbuilding, 456; sugar-beet production in, 167, 171; sunflower seed oil, 238; textile machinery, 438; waterpower, 335-36; wool manufacturing, 542. *See also* West Germany
Gilchrist, Percy, 348
Gilmore, Melvin R., 105
ginger, 199
glass industry, 430-32
Gloversville, N. Y., 259, 277
gloves, American, 259; French, 258
goats, 217-18, 254, 517-18
gold, 413-16
Gold Coast, cacao, 196, 198; gold, 416
Goodrich Co., B. F., 265
goods. *See* commodities
Goodyear, Charles, 260, 265
Goodyear Tire and Rubber Co., 265
government, and beet-sugar industry, 170-72; and cane sugar industry, 178-79; and manufacturing, 377-78; and railroad operation, 443; and shipbuilding, 456-57; stable, as a necessity of trade, 557-59; and tobacco industry, 206; and water-power development, 334-35
grading of goods, and trade, 573
Grand Coulee Dam, 328, 333, 335, 336
Grand Rapids, Mich., furniture, 498-99
granite, 424
grape and wine industries, 151-57
graphite, 339
Grazing Act, 220
Great Britain. *See* United Kingdom
"Great circle," explained 626-27; air routes, 649-50, 652; shipping, 627, 631, 636, 637-39
Great Lakes, traffic of, 585-89; vessels of, 588-89
Great Lakes region, iron and steel industry, 357-60; lumbering, 483; shipbuilding, 458; St. Lawrence Seaway, 360, 363; steel district, 357-60, 363, 364
Great Northern Forest, climate, 55-56
Greece, sheep production, 217; tobacco, 205
Greenland, 56
Grimsby, England, fish market, 246
GR-S (Government Rubber-Styrine), 264, 265
guano, 473
Guatemala, chromite, 257; coffee, 185, 188
guayule rubber, 263
Gulf Coast, crops of, 555, 556; fishing, 249; rice growing, 101-02
Gulf of Guinea, cacao production, 198; oil palm, 238
gums, 497

Haber-Bosch process, 473
halibut, 250-51
Hall, Charles Martin, 395
Hamburg, Germany, exchange, 575; as port, 566, 567, 572
handicrafts, in Asia, 269; Chinese, 539; European wool, 542; pottery, 428
Hargreaves' spinning jenny, 531
Hawaiian Islands, and Pacific shipping, 638; sugar cane, 173, 174, 177-78, 179; sugar exports, 639; trade of, 639
Haynes, Elwood, 444
helicopters, 452, 453
helium, 452
hematite, 342
hemlock bark, 256
hemp, 525
henequen, 527-28
Heroult, Paul, 395
hides, defined, 254
High Point, N. C., furniture, 499
Himalaya Mountains, tea, 193-94
hinterlands of seaports, 563-69
Hitler, Adolf, 669-70
hogs, 225-27
Hokkaido Island, fishing, 252; wood pulp, 504
Holland. *See* Netherlands
Homestead Act, 219
honey, 242
Hong Kong, as entrepôt center, 569, 573
Hoover Dam, 330, 335, 336
horse, as domestic animal, 59; as source of energy, 22-23, 24
Houston, Tex., as port, 565, 566; railroad service, 581
Hungary, beef cattle, 221; corn crop, 113; lignite production, 285; tobacco production, 205
Huntington, Ellsworth, 20, 21, 50
Huntington, W. Va., glass making, 431
Hwang-Ho River, 609
Hyatt, John Wesley, 480
hydraulic power, 329, 331

icebergs, 627
ice cream, 231
Iceland, earth heat, 338; fishing industry, 246; sheep production, 212
Idaho, potatoes, 133-34
Illinois, coal production, 293; corn production, 109; ducks, 240; farm machinery manufacture, 440; hog production, 225; machine tools, 435; rubber manufacturing, 266; shoe industry, 258; tanning industry, 257; waterways, 590
ilmenite, 404-05
immigration, to U. S., 628
Imperial Chemical Industries, Ltd., 474
imports. *See* international trade
India, beef cattle, 218, 224; cinnamon, 199; climate, 51; coal, 300; corn growing, 117; cotton, 511; cotton-textile industry, 538-39; fish catch, 253; flax production, 118, 119; ginger, 199; goats, 217; goat and kidskin exporter, 254; importance of Suez Canal to, 640; iron ore, 333; land redistribution, 7; oxen in, 24; peanut exporter, 238; pepper, 199; pig-iron exports, 636; rice growing, 94-100 *passim;* rice trade, 103, 104; sheep production, 216, 217; shoe industry, 259; sugar-cane production, 173, 183; tanning industry, 255; tea, 191, 193-94; tobacco, 201, 204, 205; trade of, 635; waterways, 609; wheat exports, 635; wheat growing, 74, 89
India-Pakistan, millet and sorghum, 122-23; railroads, 608
Indian Yearbook, 1947, 539
Indiana, automobile industry, 447; coal production, 293; limestone, 425; rubber manufacturing, 266
indigo, 478
Indochina, anthracite production, 285; coal, 300; rubber, 262; waterways, 609
Indonesia, coconuts, 237, 475; coffee, 187; peanuts, 238; rubber production, 262, 263; and South African trade routes, 637; spices, 199; tea production, 194; tobacco exports, 204
industrial machinery, 438-39
industrial migration, of copper, 385-88; of farm machinery, 440; of lumbering, 482-83; of rubber, 265; of textile mills, 553
Industrial Revolution, 332, 435, 531-32, 542; effects of, 654-69
industrial revolutions, 62-63
inland waterways, of Africa, 611-12; of Asia, 608-09; of Europe, 602-04; of North America, 585-91; of South America, 594-97; of U.S.S.R., 605-06
internal trade. *See* under specific countries
international bargain center, 575-76
International Harvester Co., 441
International Nickel Co., 410
International Nickel Co. of Canada, Ltd., 409
International Paper Co., 503
international steel cartel, 368
international trade, in aluminum, 395; in apples, 142, 143; in bananas, 137-38; and the bargain center, 573-78; in beef and veal, 222-23; in butter and cheese, 233; in cacao, 196, 197, 198; in canned goods, 163; in cement, 427; centers for, 575; in chicle, 497-98; in citrus fruits, 146, 147, 148-49; in coal, 288-90, 294; in coconut oil, 475; in coffee, 184-85, 187, 188, 190-91; in copper, 393-94; in copra, 475; in cork, 492-93; in corn, 112, 113-15; in cotton, 514-15, 540; in cotton cloth, 535, 540; in dried fruits, 157-58; in eggs, 241; in farm machinery, 440-41; in flax, 119; in hemp, 525; in hides and skins, 254, 255, 257; in iron and steel, 362, 363, 378-79; in jute, 526; in lumber, 484, 491, 495; in machine tools, 437; in meat, 207, 216, 221; in mutton and lamb, 213, 214; in oats, 120; in palm oil, 476; in paper, 503, 504; per-capita statistics on, 559-60; in phosphate rock, 468-69; in potash, 470-471; in pottery and porcelain, 428, 429; in rice, 103-04; in ships, 456; in silk, 519, 520; in silk fabrics, 546; in soap-making materials, 475; in spices, 198-200; in sugar, 164, 174, 177, 181-83; subsidies for, 557-59; and tariffs, 558-59; in tea, 191, 192, 193, 194; in tobacco, 204, 205-06; in tropical woods, 496-97; in vegetables, 128, 129, 130, 134; in watches, 460; in wheat, 68-69, 90-93; in wool, 213, 214, 516-517; in zinc, 412-13. *See also* entrepôt trade; trade
international trade centers. *See* seaports
Iowa, chicken production, 240; corn production, 109; geese, 240; hog production, 225; oatmeal, 120

Iran, goats, 217; petroleum, 320, 323; petroleum nationalization, 8, 16, 665; petroleum settlement, 578; tea production, 194
Iraq, dates, 159-60; goats, 217; petroleum, 320
Ireland, flax, 524; linen, 546; peat consumption, 284; potatoes, 131-32
iron, 340-63; manufacture, 344-46; transportation of, 356-59; world production, 365
Iron Age, 346
iron ore, 342; Great Lakes traffic in, 584; mining, 343-44, 359; U. S. needs for, after World War II, 2
irrigation, in Africa and Asia for corn, 116; in Italy, 102; and rice growing, 95-96, 98; in Sacramento Valley, Calif., 102
Italy, aircraft production, 454; aluminum, 402; automobile industry, 450; butter production, 236; cement, 427; cheese production, 232, 235; citrus fruits, 146-47; corn growing, 116; cotton-textile industry, 535; dairy industry, 234-35; eggs, 241; Florentine leather, 258; hydraulic power, 331, 335, 372; iron and steel, 372; locomotive manufacture, 443; mineral consumption, 282; olive-oil production, 236; rayon industry, 522; shipbuilding, 456; silk manufacture, 544; silk production, 520; sulfuric acid, 465, 466; textile machinery, 438; tobacco production, 205; wheat growing, 87, 92; wine industry, 152; wool manufacturing, 542

Jamaica, ginger, 199; pimento (allspice), 200
Japan, cement, 427; climate features, 21; coal industry, 299-300; copper, 392-93; cotton-textile industry, 539-40; culture pearls, 253; fertilizers, 470; fishing industry, 245, 252-53; forests, 493; hydroelectric power, 331; imports of, 634; iron and steel industry, 375-76; mineral consumption, 282; native culture, 550; oat growing, 119; Pacific trade routes to, 638-39; paper industry, 504; population density, 209; porcelain, 429-30; railroads, 607-08; rice growing, 98, 99; rice trade, 103-04; rice yields, 101; shipbuilding, 456; shoe industry, 259; silk, 519; sulfuric acid, 465, 466; tea, 193; textile machinery, 438; tobacco production, 201, 204; water power, 337; wheat growing, 89; wheat imports, 93; wheat yield, 101
Japanese people, diet problems, 252
Jasny, Naum, 88
Java, cinnamon, 199; coffee, 184, 187; corn growing, 117; rice growing, 98, 100; sugar cane, 173; sugar industry, 180-81; tea production, 194; tobacco production, 204
jet engine, 658
Johnstown, N. Y., 259, 277
Jones, Donald F., 79
jute, 525-26

Kaiser Aluminum & Chemical Corp., 399
kaoliang. *See* sorghum
Karaganda Basin, coal, 299, 374
Katanga copper district, 390-91
Kelly, William, 346
Kennecott Copper Corp., 388, 389, 405, 417
Kentucky, coal production, 293; tobacco production, 203
Kenya, butter, 235; coffee, 190; sheep, 217; sisal, 529; tea, 194
kerosene, 306-08
kips (kipskins), defined, 254
Kitimat, British Columbia, 12, 15, 16
Korea, oats, 119
Kurile Islands, fishing, 252
Kuwait, petroleum, 320-21
Kuznetsk Basin, coal, 299, 374

labor, and automation, 658; in cacao production, 198; in cane-sugar industry, 173-74, 177; Chinese, 177; in clothing industry, 547; in coal mining, 301; in cotton growing, 507-08; in dairy industry, 235; Japanese, 177; in machine-tool industry, 437; for manufacturing, 267, 268, 273-76; mobility of, 273, 275, 276; in petroleum industry, 323; for rice growing, 99; in rubber production, 263; for sheep production, 211; in shipbuilding, 457; in silk manufacturing, 544-45; in silk production, 518-19; in small metal manufactures, 459, 460; in spice production, 198; for steel industry, 352-53; "stoop," 166, 170; in sugar-beet industry, 166, 170; in tea industry, 194; in textile industry, 536-37, 539; in tobacco production, 203
Labrador, iron ore, 2, 362, 363
Lackawanna Steel Co., 357
lacquer, 493
La Grange, Ill., locomotive manufacture, 442
Lancashire, England, cotton mills, 534
Lancaster County, Pa., tobacco, 202
land hemisphere, 632-33, 652
lanolin, 517
lard, 225-26
La Société de Nickel, 409
latex, 262, 263, 264
Latin America, cacao exports, 196; cacao production, 197; coffee, 184-85, 187; problems of, 10-12; sheep production, 217; tobacco revenues, 206. *See also* Caribbean America; Central America; South America; names of specific countries
lead, 410-11
League of Nations, 1
leather, 254-59
leather manufactures, 258-59
Le Blanc, Nicolas, 462
Le Havre, France, tidal range, 566
Levassor, Emile, 444
Lever Brothers, 476
Libbey-Owens-Ford Glass Co., 431
Liberia, iron, 362
Liggett & Myers Tobacco Co., 206
lignite, 285, 293, 294, 295, 296, 297, 300, 301; and aluminum, 401
limestone, 425
limonite, 342
linen industry, 546
Liverpool, England, air route to New York, 627; as port, 565, 567, 572; shipping to Australia, 637; and textile industry, 534; tidal range, 566
livestock. *See* names of animals
livestock feed, barley as, 121; corn as, 109, 110, 111; flax as, 118-19; millet as, 122
llamas, as draft animals, 22, 24, 26; wool of, 217, 517

Lloyds of London, 574, 575, 617
location, of automobile industry, 445-47; of chemical industry, 464; of cities and towns, 563; of clothing industry, 547, 548; of copper refineries, 384; of farm-machine factories, 440; of fertilizer industries, 473; and manufacturing, 267, 268-69, 270, 276, 438; of oil refineries, 323; of paper manufacturing, 500-01; of rayon industry, 522-23; of shipbuilding, 457-58; of steel industry, 352-53, 357, 360, 362-63, 365-66; and transportation, 272-73
Lockheed Aircraft Corp., 453
locomotives, and coal industry, 291, 303; Diesel, 303, 438; 442-43; electric, 442-43; manufacture of, 441-43
London, England, air time to New York, 644; as bargain center, 575-77; and capital for trade, 576-78; development of, as entrepôt trade center, 569, 570-72; exchanges of, 575; finance center, 276; fur market, 260; grain brokerage, 577; as port, 565, 566, 567; as rail terminus, 600; wool market, 517
Long-Bell Lumber Co., 487
longhorn cattle, 219
Long Island, N. Y., ducks, 240; potatoes, 132
Lorraine Basin, coal, 369
Los Angeles, Calif., fishing and fish canning, 251
Louisiana, natural gas, 326; rice growing, 100-02; sugar cane, 173, 174, 177, 179; synthetic rubber production, 265; tobacco production, 204
Louisville, Ky., cigarette manufacturing, 206; rubber manufacturing, 265; tobacco center, 203
lowland rice, 97, 98-100
lubricants, 308, 326
Luxembourg, coal consumption, 286; iron and steel, 343, 370; tobacco production, 205
Lyons, France, silk manufacture, 544

McCormick, Cyrus, 81, 431
mace, 200
Machine Age, beginning of, 553; coming of, 26-28; commerce of, 61-62; dependence on minerals, 278-79; inequalities of, 28-32, 43-44; in lumbering, 485; and machine tools, 433; and petroleum, 308; problems of, 43-44; and the United States, 39
machine-tool industry, 433-37
machinery, agricultural, 438-41; development and use of, 26-44; and high standard of consumption, 5-6; new developments, 655-56; for rice growing, 101-03. *See also* mechanization
Madagascar, coffee production, 190; cloves, 200; vanilla, 200
Madura, tobacco production, 204
Magdalena River, 594-96
magnesium, 279, 402-04
magnetite, 342
Magnitogorsk, 278
Maine, newsprint, 501; potatoes, 132
maize. *See* corn
Majolica ware, 429
Malaya, coconuts, 237, 475; mangrove extract exports, 256; pepper, 199; rubber production, 262, 263; tin industry, 405-06
Manáos, as rubber shipping port, 261, 262
Manchester, England, cotton mills, 533-34; as industrial center, 575
Manchuria, peanut exports, 238; soybean exports, 636; soybeans, 130; wheat growing, 89
manganese, 351
mangrove bark, 256
Manitoulin Island, fur farms, 260
manufacture, fundamentals of, 267-82
manufactured-goods ports, 567-68
manufacturing, concentration in, 276; and government aid, 277-78; location of, 267, 268-69, 270; power for, 268, 270-72, 336; raw materials for, 270
Maori Indians, 21
maple sugar, 183
Maracaibo Basin, cacao production, 197
marble, 425
Marcus, Siegfried, 444
Maria Behety, sheep shearing, 215
markets and marketing, coffee, 185; diamonds, 420; for dairy productions, 231; of fish, 248; for furs, 260; for manufactures, 268-70, 276; for sugar, 164, 174, 181; for tea, 191; for tobacco, 203, 206; of wheat, 83-84, 90-93; of wool, 516-17. *See also* international trade; trade
Marseilles, France, oil center, 475
Maryland, canning industry, 162; fertilizer plants, 473
Massachusetts, book and writing papers, 501; cotton-textile industry, 536; ducks, 240; granite, 424; Indian corn, 105-06; rubber manufacturing, 266; tanning industry, 257; textile machinery, 438
meat. *See* beef, mutton, etc.
meat consumption, 207, 209, 224
meat-packing industry, 227-28
meat-packing plants, 213, 228
Mechanical Revolution, The, 26-32, 269, 279, 282, 288, 439, 461
mechanization, of agriculture, 62-63; of cane-sugar harvesting, 174; of coal mining, 292, 294, 301; of coffee production, 187; of cotton picking, 507-09; of dairy industry, 230; of farms, 439-40; of fishing, 244; in glass making, 431; of lumbering, 485-86; in petroleum industry, 323; of poultry industry, 239; of shoe industry, 258; of sugar-beet production, 170; in tobacco industry, 201, 202, 206; of wheat farming, 81-83
Mediterranean climate, 45; and cattle raising, 222; and citrus fruits, 146-47; and fruits, 160; and peach growing, 145, 160; and sheep raising, 217; and trade, 557; and wheat growing, 75
Mediterranean Region, corn growing, 115, 116; dairy industry, 234; fishing, 246-47; olive-oil production, 236; trade of, 634; wheat in, 86-87
Mediterranean Sea, trade routes, 632-36; as waterway, 602
menhaden, 249
merchant fleets of the world, 622
Merchant Marine Act, 1936, 457
merino sheep, 212, 213, 215, 517
Merseyside, England, hide-tanning center, 258
Mesabi Range iron ore, 356, 360
metal-fabricating industries, 433-60
metals, U. S. need for, 2, 3. *See* names of specific metals
Mexico, beef cattle, 218, 222, 224; coal production, 295; coffee production, 187, 188; copper, 392; corn

growing, 115-16; goats, 217; minerals trade, 555; paper industry, 504; petroleum production, 316; railroads, 584-85; rubber production, 263; Sears Roebuck and Co. in, 669; sheep raising, 217; shoe industry, 259; silver, 416-17; sugar cane, 173; vanilla, 200
Mexico City, rail connections, 584
Michelin Rubber Co., 266
Michigan, automobile industry, 447; cement industry, 427; copper mining, 386; fur farms, 260; machine tools, 435
Middle East, petroleum, 2, 318-21, 323
migration, industrial. *See* industrial migration
milk, canned, 232; ewes', 212; fresh, 229, 231, 232; goats', 234
millet, 122-23
Millinocket, Maine, 502, 503
Milwaukee, Wis., engine manufacture, 438
minerals, 278-82, 404; distribution of, 280; life cycle, 279-80; and trade, 554-55; U. S. need for, 3; and wealth of nations, 282, 286
mining, of bauxite, 397; of coal, 301; of copper, 382-83; of gold, 413; hydraulic, 413; of iron ore, 342-43; placer, 414; shaft, 414
Minneapolis, Minn., flour milling, 89, 90
Minnesota, chicken production, 240; corn production, 110; geese, 240
Mississippi River as inland waterway, 590
Missouri, geese, 240; lead, 411; shoe industry, 258; turkey production, 240
Mobile, Ala., as port, 567*n.*, 568
mohair, 218
moisture, differences in, and trade, 556. *See also* rainfall
molasses, blackstrap, 176
molybdenum, 279-80, 351
Monsanto Chemical Co., 474
monsoon climate, 51; and rice growing, 96, 98
Montana, mustard production, 200. *See also* Butte, Mont.
Monterey, Calif., as "sardine capital," 25?
Montreal, Canada, as port, 565
Morocco leather, 218
mother-of-pearl, 253
Mozambique, tea exports, 194
mules as source of energy, 23
mustard, 198, 200
mutton, 212
myrobalans, tanning material, 256

Natal, sugar cane, 173
National Coal Board, Great Britain, 290
National Planning Association, 669
National Resources Committee, 305
National Steel Corp., 362
native cultures, 550
Nauru Island, phosphate rock, 469
natural gas, 270, 304, 309, 312, 326-27, 430; as fuel for rice irrigating, 101, 102
naval stores, 498
Near East, economic status of, 7; sheep production in, 217
neoprene rubber, 264
Netherlands, cacao industries, 196; cheese production, 232, 233; coal, 296; cotton-textile industry, 535; flax, 524; foreign trade, 552; iron and steel, 370; mustard, 200; sheep, 216; shipbuilding, 456; wool manufacturing, 542
Nevada, copper, 387-88
New Caledonia, chromite, 257; nickel, 409
Newcastle, England, 289
New England, cotton mills, 536-37; cotton mills migration, 553; lumbering, 486; machine-tool manufacture, 435; manufacturing in, 258, 332-33, 336, 438; shoe industry, 258, 438; shipbuilding, 458; small metals manufactures, 459-60; trade of, 560; water power, 332-33, 336; wool manufacturing, 542-43
Newfoundland Banks, fishing, 247-48
New Hampshire, cotton textile industry, 536; shoe industry, 258
New Jersey, glass industry, 430; hog production, 227; rubber manufacturing, 266; silk manufacturing, 544, 545
New Jersey Zinc Co., 405
New Mexico, cotton, 511; potash, 470
New Orleans, La., as port, 565
Newport News, Va., shipbuilding, 458
New South Wales, dairy industry, 235; sheep raising, 214
New York Barge Canal System, 590
New York City, air route to Liverpool, 627; air time from London, 644; and capitalistic developments, 276, 577, 578; clothing industry, 547-48; exchanges in, 575; fur market, 260; hours of fog, 566; as port, 565, 568-69, 572; port facilities of, 566-67; tidal range, 566; as trade center, 562, 563
New York Central Railroad, 581
New York State, apples, 140-41; buckwheat, 123; canal system, 590; cement industry, 427; Erie Canal, 565, 581; grape and wine industry, 156; machine tools, 435; railroads, 581; rubber manufacturing, 266; shoe industry, 258
New York Tribune, 445
New Zealand, beef and veal, 222, 223; butter and cheese production, 232, 233, 235; climate, 21; forests, 495; meat, 207, 209, 213, 214; meat-packing industry, 228; sheep raising, 214, 216; sheep- and lambskin exports, 254; shoe industry, 259; sugar cane, 173; tallow, 475; trade routes to, 637-38; transportation, 613; wool, 214, 516
newsprint, 501-02
Niagara Falls, 329, 331, 333
Niagara River, 330, 336
Nicaragua, coffee, 185
nickel, 351, 408-10
Niger River, 611-12
Nigeria, cacao exports, 196, 198; palm oil exports, 238; peanut exports, 238; tin, 407
Nile River, 612
nitrates, Chilean, 471-72, 473, 632
nitrogen, 471-73
North Africa, caravans, 610; iron, 362; railroads, 610. *See also* French North Africa; Mediterranean Region
North America, beef cattle, 219; climates, 45, 51; fisheries, 247-53; inland waterways, 585-91; Mediterranean trade, 634; railroad routes, 579-85; statis-

tics on, 652; water power, 335, 336; wheat regions, 77. *See also* America; Canada; Caribbean America; Central America; Eastern North America; Mexico; United States
North American Aviation, Inc., 453
North Atlantic fisheries, 247-49
North Atlantic trade routes, 626-30
North Carolina, fertilizer plants, 473; peanut production, 238
North Europe, civilization of, 33-34; fishing, 246; manufacturing in, 269, 270, 272; oats, 119, 120; rye, 117-18; waterways, 602-04
North Pacific trade routes, 638-39
North Sea, fisheries, 246, 247; shipping route, 602
Norway, aluminum, 402; coal consumption, 303; dairy industry, 234; fishing industry, 245, 246; hydroelectric power, 331, 335; paper industry, 504; water-power resources, 331
nutmegs, 200
nuts, tropical, 238, 497
Nyasaland, tea exports, 194
nylon, 545

oak bark, 256
oatmeal, 119, 120
oats, 119-20
ocean ships and shipping, 614-25
ocean trade routes, 626-42
Oceania, cacao exports, 196; coconuts, 237, 475; coffee, 185, 187; vanilla, 200
Oder River as waterway, 603
Oersted, Hans Christian, 395
Ogden, Utah, sheep slaughter, 215
Ohio, automobile industry, 447; book paper manufacture, 501; machine tools, 435; pottery, 429; rubber manufacturing, 266; sandstone, 425
oil, crude, 308, 309; fuel, 287, 290; illuminating, 306; palm, 238, 475-76; for soap making, 475-76; vegetable, 235-38, 326, 475-76; whale, 306. *See also* petroleum
Oklahoma, natural gas, 326
Olds, Ransom E., 444
oleomargarine, 235-36
olive oil, 236, 306, 475
Omaha, Nebr., meat-packing industry, 227-28
open-hearth process, 346-47
Oregon, lumbering, 487; turkey production, 240; water-power development, 336
Orient. *See* Asia
Orinoco River, 596
orlon, 523
Otto, Nathan, 444
overdeveloped countries, United Kingdom as, 72
Owens, Michael, 431
oxen as source of energy, 22, 23-24
oysters, 249, 251; and pearls, 253

Pacific Coast, fishing, 250-51; water-power development, 336
Pacific Northwest, apples, 140-41; water-power resources, 331, 336
Pacific Ocean, air routes, 650; trade routes, 637-40
Pakistan, cattle raising, 224; coal, 300; corn growing, 117; cotton, 511; cottonseed exports, 238; goats, 217; jute, 526; tea, 193; tobacco production, 204; wheat growing, 89. *See also* India-Pakistan
palm oil, 238, 475-76
Pan American World Airways System, 646, 647
Panama, ship registry in, 624. *See also* Canal Zone
Panama Canal, compared to Suez, 641-42; importance of, 640-41; and Pacific Ocean shipping, 638; and South American trade, 632
Panama disease, 139
Panama Railroad, The, 585
paper, 499-504
Para, as rubber shipping port, 261, 262
paraffin, 308, 309
Paraguay, beef and cattle, 224; quebracho extract, 255; tobacco, 205; waterways, 597
Paraguay River, rail connection, 593
Parana-Paraguay river system, 597
Paris, as fashion center, 550; as rail center, 600
passenger ports, 567
Pasteur, Louis, 653
Patagonia, sheep production, 211, 212, 215
patch farming, 58-59
peaches, 144-45
peanut oil, 415
peanuts, 237-38
pearls, 253
peat, 283, 284, 297
Pennsylvania, book and writing papers, 501; buckwheat, 123; cement, 427; chicken production, 240; coal, 292-93; glass industry, 430; rubber manufacturing, 266; silk manufacture, 545; tanning industry, 257; tobacco, 202
Pennsylvania Railroad Co., 581, 633
Pennsylvania Rock Oil Co., 306
pepper, 198-99
"perique" tobacco, 204
Perkin, W. H., 476
Peru, and Amazon River, 596; coal production, 295; copper, 390; corn growing, 115-16; petroleum, 317; railroads, 594; rubber production, 261; sheep production, 217; silver, 417; sugar mill, 175; tobacco monopoly, 206
Petersburg, Va., tobacco market, 203
petroleum, 270, 287, 288, 304, 306-24; as bunker fuel, 627-28, 633, 637, 638; Great Lakes traffic in, 586, 587; in Saudi Arabia, 71; U. S. needs for, after World War II, 2
petroleum substitutes, 325-27
Phelps Dodge Copper Co., 388, 417
Philadelphia, Pa., carpets, 542, 543; cigar manufacturing, 206; as industrial center, 575; leather-making center, 257; as port, 568; textile machinery, 438
Philippine Islands, abaca, 526-27; chromite, 257; coconuts, 237, 475; corn, 117; forests, 496; Pacific Ocean shipping of, 638, 639; rice growing, 99; sugar cane, 173, 177, 178, 179; tobacco exports, 204
phosphate rock, 468-69
pig iron, 345, 360
pilchard (sardines), 251
pimento, 200
Pinar del Rio, tobacco, 204
pipelines, natural gas, 326; petroleum, 312, 315, 317, 318, 320, 323-24
Pittsburgh, Pa., engine manufacture, 435

Pittsburgh Plate Glass Co., 431
Pittsburgh-Youngstown steel district, 355-57, 363
plantation agriculture, 49
plantations of rubber, 262-63
plastics, 478-80
Plata, La., meat-packing plants, 228
Plata, Rio de la, 597; ocean trade of, 631
platinum, 418
Point Four, 5-6, 15, 16
Poland, coal, 287, 296-97; iron and steel, 372; peat, 284; rye, 117-18
polar regions, civilization in, 19-20
polenta, 115
politics, and aviation, 647-48; and trade, 557-59
population, birth and death rates, 653; of continents, 633
population density, and commercial spice industry, 198, 199; Grenada, West Indies, 200; Jamaica, 200; Japan, 209; and meat eating, 209, 210; New Zealand, 214; Penang, 200; and tea production, 192, 194; and trade, 551-53; United States, 209-10; Uruguay, 209; Zanzibar and Pemba, 200
porcelain, 425-30
Portland Cement, 426-27
ports. *See* seaports
Portugal, cork, 492; corn growing, 116; wine industry, 154
potash, and magnesium production, 402; and tobacco growing, 202
potatoes, sweet, 134-35; white, 130-34
Potomac River, 330
pottery, 428-29
Pottsville, Pa., coal mining, 292
poultry industry, 238-42
power. *See* electricity; energy; hydroelectric power; water power, etc.
power-driven machinery. *See* machinery; mechanization
power sources, atomic energy, 339; earth heat, 338; solar energy, 338-39; tides, 337-38; water, 270, 304-05, 328-37; wind, 337
precipitation. *See* rainfall
prehistoric civilization, 18, 22; copper and bronze, 380; corn, 105; fishing in, 243; iron used in, 345; manufacturing in, 267; nonmetallic minerals used in, 421; textiles, 530
President's Materials Policy Commission, 2-3
Pribilof Islands, fur seals, 251
price control, of U. S. farm products, 64-67
price determinants, of coffee, 189-90; of tobacco, 201-02, 204
prices, and agricultural machinery, 439; of aluminum, 395; of automobiles, 448, 450; in crude-rubber industry, 262-63; and fur farming, 260; of lumber, 484; of magnesium, 402; of paper-making industry, 500; of precious metals, 418; of titanium, 404; of vegetables, 126
primitive agriculture, 57-59
private enterprise, possibilities for, 668-69
Proctor & Gamble Co., 476
prunes, 158
Puerto La Cruz, 316
Puerto Rico, sugar cane, 173, 177, 178, 180; tobacco exports, 204
Puget Sound Pulp & Paper Co., 490
pulse plants, 128-30
Punta Arenas, meat-packing plants, 228

quarrying industry, 423-25
quebracho, 255
Queen Elizabeth, S.S., 566, 615, 644
Queen Mary, S.S., 644
Queensland, cattle production, 214

rabbits, 242, 260
railroads, of Africa, 610-11; of Asia, 606-08; of Europe, 599-602; of North America, 579-85; of South America, 591-94; of U.S.S.R., 604-05
railway-car manufacture, 441-42
railway repair shops, 442
rainfall, Argentina, 214; Australia, 213; and coffee growing, 186; and cotton growing, 506; and fertilizer consumption, 469, 474; and sheep raising, 211, 212, 213, 214, 215; and tea culture, 191, 192, 193, 194, 195
raisins, 158
Rambouillet sheep, 215
ramie, 524-25
raw-material ports, 567
rayon, 520-23, 545-46
Red Swiss cow, 229
re-export trade. *See* entrepôt trade
refineries, petroleum, 323
refrigeration, and beef marketing, 222-23, 227; and dairy industry, 235; and sheep growing, 213; and vegetable industries, 124
reindeer as draft animals, 24
research, developments in, 656-57
reserves, of bauxite, 397-98; of coal, 294, 297, 299, 300; of copper, 393-94; of iron ore, 344; of minerals, 279; of petroleum, 315, 320; of phosphate rock, 468; of potash, 470; of zinc, 413
Reynolds Metals Co., 399
Reynolds Tobacco Co., R. J., 206
Rhine River as waterway, 602-03
Rhode Island, ducks, 240; machine tools, 435
Rhodesia, Northern, copper, 390-91; Southern, chromite, 257; tobacco exporter, 205
rice, 94-104
Richmond, Va., cigarette manufacturing, 206; tobacco center, 203
Rio de Janeiro as port, 593
rivers, and growth of ports, 565-66. *See also* inland waterways; names of specific rivers
Rochester, N. Y., camera industry, 277; glass making, 431
Roebuck, John, 462
Rosario, meat-packing plants, 228
rosin, 498
rubber, crude, 260-65, 497; reclaimed, 263-64; synthetic, 264, 308
rubber manufacture, 265-66, 308
Ruhr River as waterway, 603
Ruhr Valley, coal, 295-96, 366; iron ore, 367-68
Rumania, corn crops, 113, 115; petroleum, 318
Russell, Bertrand, 669-70
Russia. *See* Union of Soviet Socialist Republics

Rust, John, 439
rye, 117-18

Saar Basin, coal, 296, 368-70; steel, 368
St. Lawrence Power Enterprise, 336
St. Lawrence River, 330, 336; canals of, 589-90
St. Lawrence Seaway, 590
St. Louis, Mo., fur market, 260; oil refineries, 323; railway-car manufacture, 442
Sakhalin Island, fishing, 252
salmon fishing and canning, 250, 251, 252
Salt Lake City, Utah, rail connections, 582
Salvador. *See* El Salvador
Sambre-Meuse area, coal, 369
San Diego, Calif., fishing, 251, 252
San Francisco, Calif., as port, 568
sandstone, 425
Sanitary Revolution, 653-54
Santa Fe Railroad, 582
Santa Gertrudis cattle, 225
São Paulo, Brazil, as port, 593
sardines, 251
Saudi Arabia, petroleum, 71, 320-21; petroleum profits, 555
savanna, defined, 49
Schenectady, N. Y., locomotive manufacture, 442
Schuman Plan, 372-73, 599
scientific knowledge and production, 550-51
Scientific Revolution, 653
Scranton, Pa., coal mining, 292
sea water, magnesium from, 402-04; possibilities of, 657
seal. *See* fur seal
seaports, classification of, 567-68; development of, 564; facilities of, 566-67; New York City as first, 563; and their hinterlands, 563-69
Sears Roebuck and Co., Mexican activities of, 669
shad, 249
shale oil, 325
Shamokin, Pa., coal mining, 292
Shanghai, China, cotton mills, 539
Shantz, H. L., 49
share cropping, 203
shea nut, 238
sheep-raising industry, 209, 210-17
Sheffield, England, 346, 366, 460
Sherritt Gordon Mines, Ltd., 409
shipbuilding, 454-59; of specialized ships, 619-20
shipping, 612-25; by airplane, 648-49; and Lloyds of London, 574, 575, 617; postwar status, 624-25; U. S. costs, 659-60
ships, chartering of, 617-18; fishing, 243-44, 456; Great Lakes, 588-89; on Mississippi River, 590-91; tramp, 617, 619-20, 621
shipyards, U. S., 457, 458
shoddy, 541
shoemaking, 258-59; Boston as center for, 575
Sicily, sumac industry, 256
siderite, 342
Siemens, William, 346
Sierra de Los Organos, tobacco growing, 204
silk, 512-20; manufacture, 544-46
Silliman, Benjamin, Jr., 321
silver, 416-18
sisal, 528-29
skins, defined, 254
slate, 425
Slater, Samuel, 536
slavery in U. S., 101
small grain, potato, and grass climate, 54-55
small metal manufactures, 459-60
soap, 474-76
soda ash, 462, 466-67
sodium nitrate, 281
soil conservation, 664
Soil Conservation Service, 511
soil erosion, examples of, 662-63; U. S., 666
soils, black, 54, 77; buckwheat's effect on, 123; for cacao tree, 196; chernozem in U.S.S.R., 87; for coffee growing, 186; for corn, 108, 116; differences in, and trade, 555-56; of Europe, 117; fertilizing of, 473; for rice, 96; for sugar-beet production, 166; for sugar cane, 173; for tea culture, 193; for tobacco growing, 201; tobacco's effect on, 202; tropic, 48-49; for vegetables, 125, 126, 131, 134, 135; wheat's effect on, 84, 92
solar engine, 657
sorghum, 122-23, 183
South, The, U. S., cattle ranches, 221; cotton production, 509-10; cotton-textile industry, 537-38; lumbering, 486-87; railnet of, 581; steel industry, 362; wool manufacturing, 543
South Africa, coal industry, 300-01; citrus fruits, 147; forests, 495; grapes, 155; railroads, 611; shoe industry, 259; tallow, 475; tanning industry, 255; trade of, 637; uranium, 339. *See also* Union of South Africa
South African trade routes, 636-37
South America, beef cattle, 219; coal imports, 632; coffee production, 187, 188-89; climates, 47, 51; east-coast trade route, 630-32; population distribution, 592; rice growing, 100; railroads, 591-94; rivers of, 594-97; railroad statistics, 584; sugar cane, 173; tobacco production, 205; west-coast shipping, 632. *See also* specific countries
South Carolina, rice, 95, 101
South Dakota, corn, 110
South St. Paul, Minn., meat-packing industry, 227-28
Southeast Asia, corn growing, 116-17; rice trade, 104; sugar cane, 173. *See also* Oceania; names of specific countries
Southern Pacific Co., 582
Soviet Union. *See* Union of Soviet Socialist Republics
Soy Bean Digest, 130
soybean oil, 130, 238
soybeans, 129-30; as fertilizer, 473; Manchurian exports, 636
Spain, citrus fruits, 146-47; corn growing, 116; cotton-textile industry, 535; grape sales and British capital, 576-77; goats, 217; iron and steel, 362, 372; olive-oil production, 236; sugar cane, 173; wine industry, 154
spices, 198-200
sponges, 249
Stamp, L. Dudley, 440
standard of consumption, in Asia, 33; in Egypt, 70; factors influencing, 5-6; in United Kingdom, 72
Standard Oil Co., South American oil, 632

steam coal, 289, 295
steam engine, invention and development, 26, 28
steamboats, and coal industry, 291
steel, alloy, 351, 408-09; basic, 347-48; and iron, 340-63; steps in making, 344-51; uses of, 340-42; world production, 351, 365. *See also* steel industry
Steel Age, 351
steel industry, American, 355-63; Asiatic, 375-77; European, 364-75; flow in, 348, 349, 351-52; locational factors, 352-53, 357, 360, 362-63; nonferrous metals used in, 350; Southern Hemisphere, 377-78
steppe, defined, 49
Stone Age, 380
Stone Age agriculture, 58
Strasbourg, France, leather-making center, 258
subbituminous coal, 285, 293, 294, 295, 299
subtropic climate, 47
Suez Canal, compared to the Panama, 641-42; and Egypt, 8; importance of, 640, 641
sugar beets, 164-68; and barley in crop rotation, 122
sugar industry, 164-83
sulfur, 466; in rubber vulcanizing, 261, 265
sulfuric acid, 462, 464-66
Sumatra, coffee production, 187; tea production, 194; tobacco production, 204
sunflower-seed oil, 238
Sweden, dairy industry, 234; iron and steel, 343, 362, 370-72; paper industry, 503-04; shipbuilding, 456; sugar-beet production, 166; water-power, 331, 335, 372
sweet corn, as vegetable, 110
swine, 225-27
Switzerland, chocolate factories, 196, 234; cotton-textile industry, 535; dairy industry, 234; forestry, 492; hydroelectric power, 331, 335; silk manufacture, 544; textile machinery, 438; trade of, 555; watchmaking, 460; water connection to, 602-03; water-power resources, 331; wool manufacturing, 542
synthetic fibers, 520-23

taconite, 360
tallow, 212, 219, 475
Tampico, Mexico, oil shipments, 316
tanbarks, 255-56
Tanganyika, butter exports, 235; coffee production, 190; sisal, 529; tea exports, 194
tanneries, 257
tannin, 255
tanning industry, materials for, 255-56; process, 256-58
tariff protection and international trade, 557-59
tariffs, in Europe, 599; U. S. policy on, 660-61, 664; and wheat imports, 92-93
tea, 191-95; brick, 193; cultivation of, 191-92; eucalyptus, 195; miscellaneous kinds of, 195
temperate regions, civilization in, 20-22
temperatures, ideal, for man, 20; and water power, 331
Tennessee, marble, 425; phosphate rock, 468; rayon industry, 522
Tennessee Valley Authority, 278, 335
Texas, cement industry, 427; chicken production, 240; citrus fruits, 151; natural gas, 326; petroleum, 314-15, 323; sheep production, 215, 216; rice growing, 101-02; synthetic rubber production, 264-65; steel industry, 362; turkey production, 240; vegetables, 125, 127
textile industry, and chemical industry, 462; early, 26, 28. *See also* cotton-textile industry; silk; woolens, etc.
textile machinery, 437-38
Thailand, pepper, 199; rice growing, 96, 97; rubber production, 262; tin, 406; waterways, 609
Thomas, Sidney, 348
thorium, 339
tidal power, 337-38
Tierra del Fuego, sheep raising, 212, 215
tile, 422-23
Timbuktu, 612
tin, 405-08
Titanic, S.S., sunk, 627
titanium, 279, 404-05
Titusville, Pa., petroleum, 306, 315, 326
tobacco growing and trade, 200-06
topography, differences in, and trade, 555
Toronto, Canada, meat-packing industry, 228
towns, origins of, 561-62. *See also* cities
trade, bases of, 550-60; definitions of, 550, 560; and the Machine Age, 61-62. *See also* international trade
trade agreements, coffee, 190; sugar, 181-83
trade centers, development of, 561-78
trade routes of the world, 626-42
tramp shipping, and canal tolls, 640; cargoes of, 615, 616-17; decline of, 618-24; future of, 623-24; on ocean routes, 629, 631, 635, 636, 637, 639
tramp ships, charter of, 616; London as charter center for, 575; management of, 617-18
transportation, and coal industry, 291, 294; and growth of cities, 563; and manufacturing, 269, 270, 272-73. *See also* inland waterways; railroads; tramp shipping, etc.
Trans-Siberian Railroad, 605
trap rock, 425
Trinidad, petroleum, 317
Tripoli, as port, 565
tropic climate, as asset in trade, 556, 557; civilization in, 18-19; for rice, 95-96, 97-98; soils of, 48
tropical forest climate, bananas in, 137; cattle raising in, 224
tropical grassland climate, 49-51; and sugar cane, 173
Troy, N. Y., shirt and collar industry, 227
truck farming, 125-26
trunk routes. *See* trade routes of the world
Tsai Lun, 499
tuna, 251
tundra, 56
tungsten, 351
Tunis, olive trees, 236
Turkestan, caravan routes, 607
Turkestan-Siberian Railroad, 605
Turkey, chromite, 257; goats, 217, 218; problems of acquiring capital, 9-10; tobacco, 201, 204, 205; valonia exporter, 256
turkeys, 240
turpentine, 498
Twentieth Century Fund, 7, 668
two worlds, Americans discover, 1-17

Uganda, butter exports, 235; coffee production, 190, 191; peanut exports, 238; sheep production, 217; tea exports, 194
underdeveloped countries, Egypt as, 69-71; capital needed by, 7-9, 665, 668-69; Latin-American problems, 10-12; Near East problems, 8-10; needs of, 15-17; problems of, 4-6; prospects for, 14; psychological problems of, 9-10; and wheat, 93
Union Carbide Co., 464, 523
Union of South Africa, beef cattle, 218; beef imports, 223; chromite, 257; diamonds, 419, 420; gold, 414-15; platinum, 418; railroads, 610; sheep production, 215; steel industry, 377; wattle bark and extract exports, 255; wool, 516
Union of Soviet Socialist Republics, aircraft production, 454; aluminum, 401; anthracite coal production, 285; automobile industry, 450; barley growing, 122; beef cattle, 218, 221-22; bituminous coal production, 286; cement, 427; climate regions, 54, 55; coal, 297-99, 303, 336; coal consumption, 287; copper, 392-93; corn crops, 113; cotton, 511-12; cotton textiles, 535; dairy industry, 234; farm-machinery manufacture, 441; fishing industry, 245; flax, 118, 119; forestry, 492, 493; glass industry, 432; goats, 217; gold, 415; grain exports, 635; inland waterways, 605-06; iron mining, 343; leathermaking, 257, 258; lignite production, 285; lumbering, 491; locomotive and railway car manufacture, 443; and manufacturing, 278; meat-packing industry, 228; Mechanical Revolution in, 34-38; millet growing, 122; mineral consumption, 282; mineral production, 282; mineral reserves, 279, 280, 282; natural gas, 326-27; nickel, 409; oats, 120; peat consumption, 284; per-capita trade of, 560; petroleum, 318, 323; phosphate rock, 469; platinum, 418; potatoes, 132; railroads, 579, 583, 604-05; rubber manufacturing, 266; rye production, 117, 118; sheep production, 216; shipbuilding, 456; soils of, 54, 87; statistics on, 652; steel industry, 373-75; sugar-beet production, 167-68, 181, 183; sulfuric acid, 465, 466; sunflower-seed oil, 238; tea production, 195; textile machinery, 438; tobacco production, 201, 205; water power, 336; wheat growing, 87-88, 90, 91, 92; and world domination, 3, 4
United Fruit Co., 138, 527
United Kingdom, aircraft production, 454; airflight restrictions by, 646-48; anthracite production, 285, 288, 289; automobile industry, 450; barley growing, 121; beef cattle, 221, 222; bituminous coal, 286, 288, 291; cement, 427; chemical industry, 462, 465; coal consumption, 286, 291, 303, 336; coal exports, 289-91, 632, 635; commerce problems of, 72; cotton textile industry, 533-35; dairy industry, 232-33; entrepôt trade, 571-72; farm-machinery manufacture, 441; fishing industry, 245, 246; geographical location of, and trade, 559; glass industry, 432; helicopters, 452; hides and skins, 255, 257; iron and steel industry, 343, 364-66; jute, 526; leather making, 257, 258; locomotive manufacture, 443; machine-tool industry, 437; and manufacturing, 278, 437-38; meat importer, 214; merchant marine, 625; mineral consumption, 282; mineral production, 282; mineral reserves, 279; nickel, 409-10; overdeveloped country, 72; petroleum, 323; potatoes, 132; rabbit imports, 242; rayon industry, 522; registered vessels, 623; rubber manufacturing, 266; sheep production, 216; shipbuilding, 455-56; sugar-beet production, 168; sugar industry, 180-81; sunflower-seed oil, 238; textile machinery, 438; tin, 407; wheat, 86, 92; wool importer, 214
United Nations, position of small nations in, 3-4; as referee for capital investments, 665, 668; report of, on world situation, 14; technical assistance program, 15-17
United States, agriculture, 60-67; aluminum, 396, 397, 399-401; air position of, 652; air problems of, 647-48; air traffic statistics, 649; airlines, 644, 646; airplane manufacture, 453-54; anthracite coal production, 285, 291-92; attitude toward U.S.S.R., 3; automobile industry, 445-50; barley production, 121; beef cattle, 218-21; bituminous coal production, 286, 291-295; brick and tile industry, 422-23; buckwheat production, 123; butter and cheese, 232; cane-sugar production, 179-80; capital acquisition, 6-7; capital and international trade, 577; capital investments, in Brazil, 13, in Canada, 2, 13, in railroads, 614; cement industry, 426-27; chemical industry, 461, 463-64; chicken production, 240; citrus fruit industry, 148-49; climate features, 21, 51, 52-53; clothing industry, 547-48; coal consumption, 287, 303; coffee consumption, 184, 185; copper, 385-88, 394; corn exports, 114-15; corn production, 105-11, 112; *see also* Corn Belt, U. S.; cotton, 505, 509-11, 514-15; *see also* Cotton Belt, U. S.; cotton exports, 661; cotton-textile industry, 535-38; cottonseed oil, 238; dairy industry, 230-32; dried fruits, 157, 158, 160; dye industry, 478; economic isolation, 659-61, 664; electric-power industry, 272; export problems, 67-68; farm population, 63; farmers' plight, 30; fishing industry, 245; flax growing, 119; flour milling, 89-90; geographical location of, and trade, 559; glass industry, 430-31; glove industry, 259; gold, 416; grape and wine industry, 156-57; hides and skins, 254; immigration, 628; inanimate energy, 40-41; inland waterways, 585-91; interest of, in undernourished peoples, 3-4; international bargain centers of, 578; international trade of, 552-53; iron mining, 343; land area distribution, 667; locomotive and railway-car manufacture, 441-43; lumbering, 483-87; and Machine Age, 39; magnesium, 402-04; meat industry, 207, 216; Mediterranean imports, 634; merchant marine, 622, 624-25; millet production, 123; mineral "boom and bust," 555; mineral production, 280, 282; mineral reserves, 279; natural resources, 664; oat production, 119-20; oil fields, 311-15; Pacific Ocean shipping, 638-39; Pacific trade routes, 638-39; paper, 500-03; peanut production, 238; pepper imports, 199; per-capita trade of, 560; petroleum industry, 308, 323, 324; petroleum production, 311-15, 318; phosphate rock, 468-69; pig-iron production, 282; population density, 209-10; population problem, 654; ports of entry, 568; potash, 470-71; poultry industry, 238-39; price supports, 559; primitive agriculture, 57, 58; railroads, 41, 579-83, 586; rayon industry, 522-23; rice growing, 101-03; rice introduced, 95; rice yield, 101; rural energy, 38-39; rye production, 118; seaports, principal, 568-69; sheep production, 215-16; ship-

building, 457-58; shoe industry, 258-59; silk and rayon industries, 544-46; silver, 417; slavery in, 101; soap industry, 476; soil erosion, 662-63, 666; soils, 75, 76; sorghum production, 123; steel industry, 282, 351-53, 355-63; sugar-beet production, 168-69, 171; synthetic rubber production, 265; tin, 407-08; tobacco, 201, 203-04, 205-06; unemployment problems, 659; uranium, 339; vegetable industries, 124-28, 130, 132, 134; water power, 331, 332-36; waterfront ownership, 567; wheat growing, 73-77; wheat yield, 101; *see also* Wheat Belts, U. S.; wool importer, 216; wool manufacturing, 542-44; work done by animals in, 22; in World War II, 658-59; zinc, 412. *See also* South, the; West, the
United States, S.S., 644
United States Army, air transport command, 649; forces abroad, 3, 4
United States Bureau of Mines, 325, 326
United States Census, 1850, 257
United States Department of Agriculture, and food surpluses, 64-68; wheat varieties, 79
United States Fish and Wildlife Service, 245
United States Forest Service, 485, 490
United States Government, aid to Europe, 3, 5; and Alaskan Railroad, 582-83; and Mississippi River system, 591; and Point Four, 5-6; tariff policy, 558, 660-61, 664
United States Rubber Co., 265
United States Steel Corp., 356-57, 362; Fairless plant, 7, 66; South American ore, 596
upland rice, 97-98
Upper Silesia, coal, 296; steel, 368
uranium, 339
Uruguay, beef and veal, 222, 223; meat consumption, 207; meat-packing industry, 228; ocean trade of, 631, 632; population density, 209; railroads, 592-93; sheep production, 209, 215, 216; shoe industry, 259; waterways, 597; wool, 516
Utah, copper, 387-88; steel industry, 362-63

valonia, 256
vanadium, 351
vanilla, 200
varro, 242
vegetables, 124-36; canned, 128, 160-63; frozen, 163
Venezuela, beef cattle, 224; cacao production, 196, 197; copper production, 188, 189; iron ore, 2, 362, 363, 596, 632; natural gas, 327; petroleum, 316, 317, 318; petroleum profits, 555; railroads, 594
Venice, as entrepôt center, 570
Vermont, granite and marble, 424-25
Victoria, New Zealand, dairy industry, 235
vicuña, 217, 517
Virginia, apples, 140, 141; crop rotation, 121; fertilizer plants, 473; Indian corn, 105-06; peanut production, 238; rayon industry, 522; tobacco, 202
Volga River, 605
vulcanization of rubber, 265

wage standard in U. S., 659-61
Washington (state), apples, 140, 141, 142; lumbering, 487; water-power developments, 336
Washington, D. C., location of, 563
water buffalo used in rice growing, 99
water power, 270, 304-05, 328-37. *See also* energy
water transportation. *See* inland waterways; ocean ships and shipping
water wheels, 26, 27
Watt, James, 26
wattle bark, 255, 495
weather, and aviation, 646. *See also* climate; rainfall
West, The, of U. S., cattle ranches, 220-21; lumbering, 483, 487; railnet of, 581-82; steel industry, 362-63
West Africa, cacao, 196, 198; coffee, 184-85, 190-91
west-coast marine climates, 52
West Europe, apples, 143; Australian, New Zealand trade of, 638; high standard of consumption, 5, 6; meat-packing industry, 228; Mediterranean trade of, 634; railroads of, 599-601; U. S. aid to, 3; waterways of, 602-04. *See also* names of specific countries
West Germany, butter and cheese production, 232, 234; leather making, 257, 258; machine-tool industry, 437
West Indies, cacao production, 197; coffee, 184, 187, 188; petroleum, 318, 323; vanilla, 200
West Virginia, coal mining, 293
Weyerhauser Timber Co., 484, 487
wheat, 73-93; cutting of, 58, 61, 81; climate for, 54, 73-78; gradability of, and international trade, 573; as grain food, 94; Great Lakes traffic in, 586, 588; and rye compared, 177; U. S. prices of, 66-67; technology of, 78-83
Wheat Belts, U. S., 74, 76, 84-85; barley in, 121; flax in, 119
wheat milling. *See* flour milling
White Pass & Yukon Railroad, 582
Whitney, Eli, 435, 505
Wickham, Henry A., 262
Wilkes-Barre, Pa., coal mining, 292
Wilson, N. C., tobacco market, 203
Wilson, Woodrow, 1
wind power, 337
windmills, 26, 27
wine. *See* grape and wine industries
Winnipeg, Canada, meat-packing industry, 228; rail connections, 583
Winston-Salem, N. C., cigarette manufacturing, 206; tobacco market, 203
Wisconsin, cheese making, 232; farm-machinery manufacture, 440; fur farms, 260; tanning industry, 257; tobacco production, 204; writing-paper manufacture, 501
Wöhler, Friedrich, 395
wood, 481
wool, 212-17, 515-18
wool manufacturing, 540-44; carpets, 543-44
woolens or worsteds, 540-41
world, the, airways of, 643-52; birth and death rates, 653; climate regions of, 45-56; energy supply, 22, 23; overseas trade routes, 626-42; population, 633; work output, 35
World War I, effects of, on shipping, 635-36
World War II, effects of, on shipping, 624-25, 636; and Panama and Suez canals, 642; results of, 1, 2; U. S. achievements in, 658-59; and U. S. agriculture, 63-66

wrapper tobacco, 204
Wright, Orville, 451
Wrigley, Philip K., 497

yak, as draft animals, 24
Yangtze-Kiang River, 609
yerba maté, 195
Yucatan, henequen, 527
Yugoslavia, corn crops, 113; corn exports, 635; sheep production, 217; tobacco production, 205

Zambesi River, 335
Zanzibar, as entrepôt center, 570
Zeiss Opton, 432
zinc, 411-13